Research paper

Quantitative Analysis of Traditional Ecological Knowledge: A Case Study of Paiwan People in Jialan Village, Taiwan

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【Summary】

To the public, aboriginal peoples' legitimacy for co-management of the land partly comes from traditions passed down through history. In the past, traditional ecological knowledge (TEK) was transmitted by oral history, fables, and ceremonies, instead of being written down and documented. The purpose of this study was to discover existing contents and influencing factors of theoretical and practical TEK. Questionnaires were used to investigate the Paiwan people who live in Jialan Village, Jinfeng Township, Taitung County. Results showed that respondents had medium-grade theoretical TEK. However, this cognitive ability was not homogeneous across individuals. Gender and other socioeconomic factors had a significant influence on awareness of theoretical TEK. It was noteworthy that the respondents' awareness level of theoretical TEK increased with age. As for practical TEK, although the study area is near forests, about 30% of the respondents used neither plants nor animals. According to the use and collection frequencies, it is clear that these aborigines no longer wholly depend on natural resources for their daily lives. Socioeconomic factors also rarely influenced respondents' practical TEK. Finally, we found a positive and statistically significant correlation between the theoretical TEK of plants and the plants used in line with theoretical expectations.

Key words: traditional ecological knowledge, conservation, forest management, aboriginal people.

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研究報告

傳統生態知識的量化分析：嘉蘭村排灣族人的個案研究

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摘　要

原住民族共管經營土地的合法性部分來自長年存在的祖先傳統，而原住民傳統生態知識是用口語、傳說、祭典等儀式傳承下來，少有文字記載，因此本研究採問卷方式針對台東縣金峰鄉嘉蘭村排灣族原住民進行普查，探究原住民理論面與實踐面的傳統生態知識及其影響因素。研究發現理論面的傳統生態知識非均質的，性別等社經因素均對其有顯著影響，此外，年輕族群對傳統生態知識的認知程度較低，顯示知識出現流失的現象。在知識的實踐使用方面，雖然研究地點比鄰森林資源，但約三成的受訪者無使用動植物的行為，從使用頻率及方式可知原住民不再完全依賴森林資源的生活型態，但實踐面的傳統生態知識很少受性別等社經因素所影響。最後本研究發現有採集植物者，其植物方面的傳統生態知識在理論面與實踐面成顯著正相關，符合一般理論假設。

關鍵詞：傳統生態知識、保育、森林經營、原住民。

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INTRODUCTION

Since the 1980s, the application of traditional ecological knowledge (TEK) has extensively been developed. The number of published studies that refer to TEK has constantly increased, with more than 200 papers published each year, revealing the importance of TEK to natural conservation in recent years (Cheveau et al. 2008). Centralized bureaucratic resource management systems have been criticized for leading to ecological collapse and for failing to improve people's standard of living, so there is an increasing focus on collaborative processes (Houde 2007). Local collaboration enhances the robustness of ecological management decisions by enabling access to systems of knowledge and management practices that are better attuned to local specificities (Pálsson 1997). Through local collaboration, the efficiency of decision implementation can be increased by involving people that are directly affected (Sheppard and Meitner 2005), and can also improve equity in the decision-making process by moving away from a management mode that is controlled by a central state (Pagdee et al. 2006). These paradigm shifts have helped TEK be recognized internationally, especially since the *Our Common Futur*e report (UNWCRD 1987) was published, which encouraged the use of TEK to help resolve environmental resource issues in modern times (Johnson 1992).

TEK is a cumulative body of knowledge, practices, and beliefs that has evolved by adaptive processes and has been handed down through generations by cultural transmission. It is about the relationship of living beings (including humans) with one another and with their environment (Berkes 1993). "Knowledge" is a component of local observational knowledge of species and other environmental phenomena. “Practice” means the way people carry out their resource use activities. “Belief” relates to how people fit into or relate to ecosystems (Berkes et al. 2000). Some researchers use “local knowledge” to emphasize its very localness, whereas some use the label “indigenous knowledge” to refer to its uniqueness to a particular community or ethnic group (Houde 2007). Kuhn and Duerden (1996) suggested that TEK is essentially local knowledge because it is based on experience. TEK is highly dynamic and cumulative. Although it is based on the experience of previous generations, it is verified in each new generation; it is also added to and adapted, to meet present socioeconomic and technological changes. Not all traditional practices are ecologically wise either. An example was given by Fu (1997), who considered aborigines to be efficient hunters rather than conservationists. Nevertheless, TEK has become established through the work of the International Conservation Union working group, and therefore we will henceforth use TEK to describe environmental knowledge and perspectives of indigenous people living close to nature.

According to the definition by Berkes et al. (2000), the research aspects of TEK include knowledge, practice, and beliefs. Knowledge refers to a theoretical dimension or intellectual ability, such as the ability to recognize animal and plant names, ecological characteristics, and flowering seasons. Practice is the ability to apply knowledge to real life. Knowing the potential uses of a plant, for example, might not be construed as true practice since the individual might not know how to actually use the plant. Belief is the foundation of TEK, regulating the relationship between humanity and the world. Reyes-Garcia et al. (2005) found that current research focuses on aspects of theory and practice rather than beliefs. In addition, they found that researchers paid scant attention to sample size and selection, and suggested future research should consider sampling issues such as stratifying by age, gender, and other respondent characteristics. Since different socioeconomic statuses affect attitudes and decision-making concerning the access, use, and management of natural resources, many scholars began to integrate social and gender analyses into natural resource management (Agarwal 2001, Vernooy and Fajber 2006).

Cheveau et al. (2008) used the ISI Web of Science database to analyze published papers focusing on TEK from 1983 to 2005. They found 21 studies that specifically addressed forest management, of which 15 studies dealt with TEK. This highlights the importance of investigating TEK. The methods of data collection varied widely across these studies: 6 studies used a zoning process that divided the land into areas in which different land uses were emphasized, and 5 studies proposed the incorporation of traditional management rules into modern forest management plans. Ghazanfari et al. (2004) used participant observations to document traditional management practices to increase local community acceptance. Silvano et al. (2005) used a questionnaire to evaluate local perceptions about land degradation.

Domestic TEK research in Taiwan relating to forest management has mainly used a descriptive method to record plant names and how plants are used (Liu 2000, Zheng et al. 2002, Lin et al. 2004). Lu (2006) focused on the development and application of TEK in local communities. Over the years, TEK research across the world has shown a rich diversity in terms of methods and contents. In contrast, the domestic application of TEK in Taiwan to natural resource management is still in its infancy. The number of studies is sparse, research themes are limited, and quantitative methods have not been used in such studies.

Taiwanese aborigines traditionally lived by hunting, fishing, and farming. They depended on surrounding natural resources for their daily lives and developed deep interactions with their environment. A rich body of knowledge and technologies is held by tribal social institutions and organizations, and it has evolved in response to natural environmental changes over time. This body of knowledge is accumulated, constructed, and symbolized in festivals, ceremonies, taboos, and customs. Since the Japanese colonial period, however, wild-land nationalization, assimilation, and capitalism have significantly reduced interactions between indigenous tribes and their surrounding environments.

Houde (2007) asserted that aboriginal legitimacy for the co-management of land partly comes from the existence of ancestral traditions passed down over time. Although Taiwanese aborigines have a certain degree of legitimacy regarding natural resource management since the *Indigenous Peoples Basic Law* was passed in 2005, with lifestyle changes, is their current TEK sufficient for effective resource management? What are the contents of this existing TEK? Has any TEK been lost? What socioeconomic factors affect the recognition of TEK?

For the effective application of TEK to natural resource management, TEK surveys have become a primary research tool. This study used questionnaires to investigate Taiwanese aborigines' theoretical and practical knowledge and socioeconomic background information, recorded the contents of theoretical and practical knowledge, and analyzed their correlations and influencing factors by a quantitative analysis. The results will help natural resource management authorities establish forest co-management with aborigines.

MATERIALS AND METHODS

Den and Gold (1995) argued that since indigenous knowledge systems are very complex, no single method can fully capture their complexity. Two methods were used in this study to capture indigenous TEK. One method used a structured questionnaire given to villagers to gather information on theoretical and practical TEK. The other method supplemented the first by interviewing elderly villagers to set up a database of plants and animals which was used to design the questionnaire. We also selected 3 Paiwan people who could translate the names of the flora and fauna to conduct the face-to-face questionnaire surveys, to reduce communication barriers.

Hunn (2002) indicated that TEK acquisition occurs before the age of 15 yr. Following this, participants of this study were all Paiwan adults over 20 yr of age, living in Jialan Village, Jinfeng Township, Taitung County. Questionnaires were collected between June and December 2009. In all, 389 people completed the questionnaires, of which 355 were effective samples.

Design of the questionnaire

The objectives of this study were as follows: (1) investigate theoretical and practical TEK, (2) analyze factors that affect the cognition of TEK, and (3) look for correlations between theoretical and practical TEK. The questionnaire consisted of 3 parts. The first part sought to understand respondents' awareness of theoretical TEK. We referred to Osemeobo (2001), who used plant habitats, flowering periods, fruiting periods, harvesting practices, and regeneration cutting methods to assess respondents' opinion of TEK. In this study, there were 17 questions about theoretical TEK (Table 1), questions about plant knowledge (A1~A4), animal knowledge (A5~A9), land knowledge (A10~A11), and inheritance knowledge (A12~A17). We used a Likert 6-point scale to avoid a neutral (mid-point) answer. The options from 1~6 were: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, and strongly agree. The second part was the investigation of practical TEK. First, plants (29 species, Fig. 1) and animals (11 species, Fig. 2) that elderly villagers identified as being frequently used were included in the questionnaire. The use, collection time, and use frequency of those plants and animals could then be investigated. The third part was an investigation of socioeconomic background information: gender, age, education, income, class, and occupation.

The study area

The study area was located in Jialan Village, Jinfeng Township, Taitung County. In Jinfeng Township, 80% of the population are from the Paiwan tribe. The township has a total area of 38,066 ha. It is a highland tribal township, with more hilly land than plains. On the western side is the Dawu ecological protection area, while the area of development is located on the eastern side near Taimali Township. According to Jinfeng Township Office statistics, more than 90% of village households are farmers, with millet, sweet potatoes, taro, roselle, and custard apples the main cash crops. Because nearby Taimali is not far from Taitung City, most of the agricultural

Table 1. Survey contents of theoretical traditional ecological knowledge (TEK)

Plant knowledge	Land knowledge
A1: I am well aware of all the usages of plants in the forest. A2: I am well aware of all the seasons for collecting plants in the forest. A3: I am well aware of all of the growth regions in the forest. A4: I can recognize all the edible and non-edible wild plants.	A10: I know the names of major mountains nearby. A11: I am well aware of safe and dangerous parts of the rivers nearby.
Animal knowledge	**Inheritance knowledge**
A5: I am well aware of distribution areas of all of the wildlife. A6: I am well aware of the breeding seasons of all of the wildlife. A7: I can estimate the population of all of the wildlife in the forests. A8: I am well aware of hunting wildlife. A9: I am well aware of traditional hunting ranges.	A12: I am well aware of traditional norms and taboos for the usage of natural resources. A13: I am well aware of where my ancestors came from. A14: I am well aware of the meaning of all ceremonies. A15: I often use TEK learning from my tribe in my daily life. A16: My TEK mainly came from teaching by my tribe. A17: I often teach TEK to my children in our daily lives.

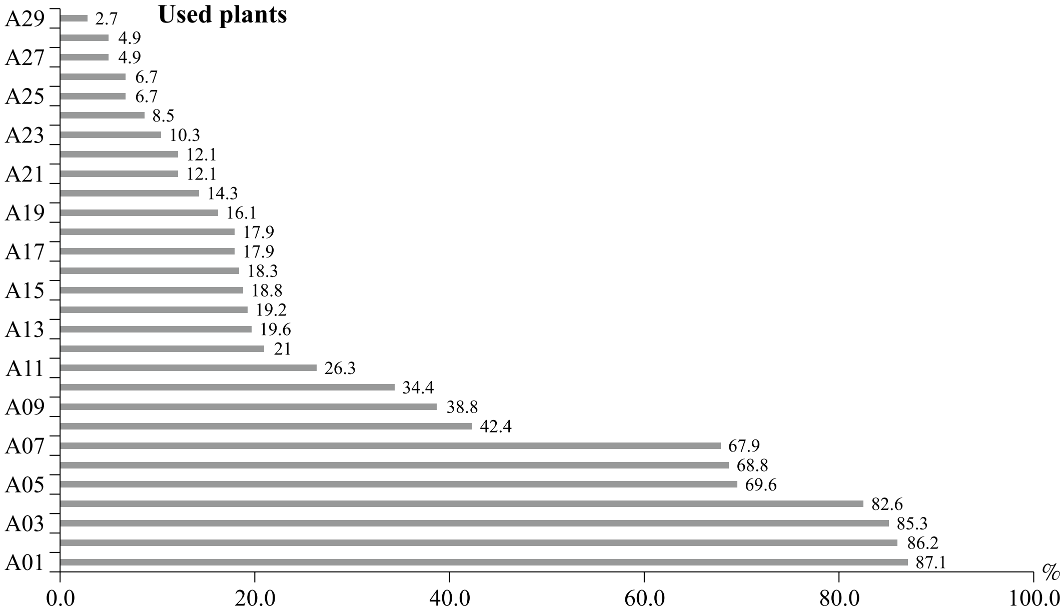

Fig. 1. Utilization rate (%) of plants.
We adopted the total number of people who used a certain kind of the plant divided by the total number of people who used plants (*n* = 224) to calculate the utilization rate. The scientific names of the 29 plants are as follows: (A01: *Crassocephalum crepidioides* (Benth.) S. Moore; A02: *Solanum americanum* Miller; A03: *Zanthoxylum ailanthoides* Sieb. & Zucc; A04: *Pseudodrynaria coronans* (Mett.) Ching; A05: *Trichodesma calycosum* Collett & Hemsl; A06: *Emilia sonchifolia* (L.) DC. var. *javanica* (Burm. F.) Mattfeld; A07: *Piper umbellatum* L; A08: *Bidens pilosa* L. var. *radiata* Sch. Bip; A09: *Pterocypsela indica* (L.) C. Shih; A10: *Calamus formosanus* Beccari; A11: *Amaranthus viridis* L; A12: *Alpinia zerumbet* (Pres.) B. L. Burtt & R. M. Sm; A13: *Champereia manillana* (Blume) Merr; A14: *Hibiscus taiwanensis* Hu; A15: *Areca catechu* L; A16: *Broyphyllum pinnatum* (Lam.) Kurz; A17: *Diplazium dilatatum* Blume; A18: *Rhus javanica* L. var. *roxburghiana* (DC.) Rehder & E. H. Wils; A19: *Ehretia dicksonii* Hance; A20: *Murraya paniculata* (L.) Jack; A21: *Begonia formosana* (Hayata) Masam; A22: *Trema orientalis* (L.) Blune; A23: *Lagerstroemia subcostata* Koehne; A24: *Macaranga tanarius* (L.) Muell.-arg; A25: *Rhus succedanea* L; A26: *Fraxinus griffithii* C. B. Clarke; A27: *Lycianthes biflora* (Lour.) Bitter; A28: *Machilus japonica* Sieb. & Zucc. var. *kusanoi* (Hayata) Liao; A29: *Ficus irisana* Elmer.).

working population live a dual lifestyle of agricultural production and temporary work.

Jialan Village is situated in a traditional highland tribal territory, with many forest resources available, However, their geographical environments and lifestyles significantly differ from those of people who live on the plains, so we selected this village to explore existing aboriginal TEK.

Data analysis

First, descriptive statistics were used to determine respondents' awareness level of theoretical and practical TEK and their socioeconomic characteristics. This was followed by an analysis of variance (ANOVA)/*t*-test to determine whether different socioeconomic characteristics had a significant influence on cognition of theoretical and practical TEK.

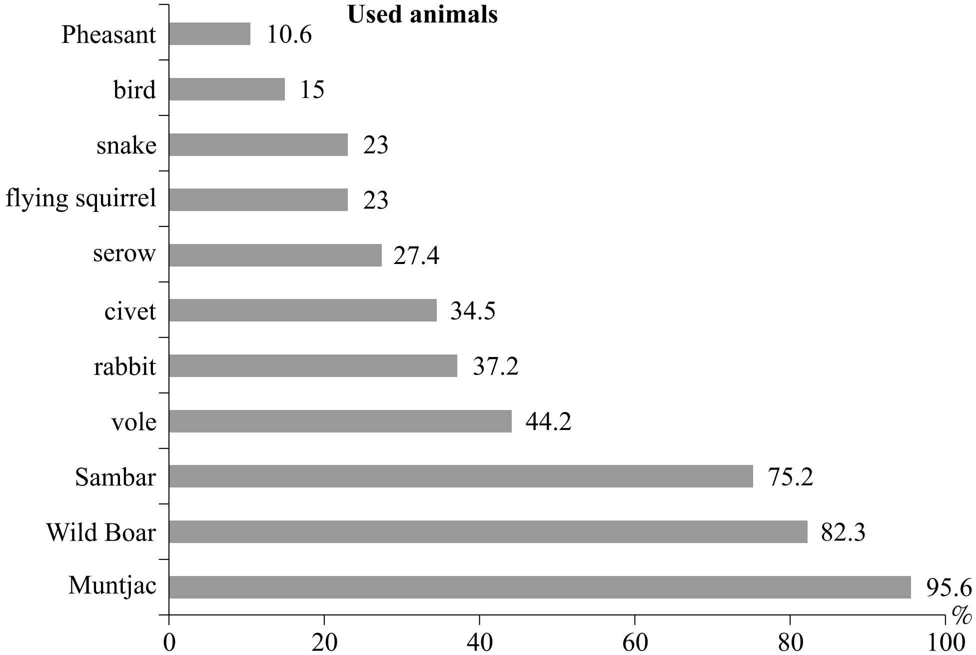

Fig. 2. Utilization rate (%) of animals.
We adopted the total number of people who had used a certain kind of animal divided by the total number of people who used animals (*n* = 113) to calculate the utilization rate.

Last, a correlation analysis was used to identify the relevance of theoretical and practical TEK.

For a quantitative analysis of the correlation between theoretical and practical TEK, this study used a data aggregation method after Reyes et al. (2006) to estimate the correlation between theoretical and practical TEK. We totaled respondents' awareness of theoretical knowledge and species used, and calculated the Pearson correlation coefficient to estimate the connection between theoretical and practical knowledge.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The socioeconomic characteristics of respondents are shown in Table 2. Proportions of male and female respondents were similar (52.7 and 47.3% of all respondents, respectively). The largest age group was 40~49 yr, accounting for 27% of all respondents, while the proportions of the remaining age groups were around 20% each. Respondents who had graduated from senior high school or above accounted for 39.7% of the total, followed by those with elementary schooling or less at 36.6% of all respondents. As for the monthly income of respondents, 69.9% earned ≥ NT$20,000, while 30.1% earned ≥ NT$20,001. In terms of respondents' occupations, those engaged in farming were the largest group at 27%, followed by the unemployed and self-employed at about 18% each. Most respondents' roles in the tribe were civilian, accounting for 76.6% of all respondents. Other tribal roles included leaders, nobles, warriors, wizards, and priests, which in total accounted for 23.4% of all respondents.

Table 2. Socioeconomic characteristics of respondents in Jialan village

Item	(%)	Item	(%)
Gender		**Personal monthly income (NT$)**[1)]	
Male	52.7	< 20,000	69.9
Female	47.3	≥ 20,001	30.1
Age (yr)		**Occupation**	
20~29	16.1	Farmer	27
30~39	18.0	Self-employed	18.6
40~49	27.0	Unemployed	18.9
50~59	22.3	Laborer	9.9
> 60	16.6	Military, civil servant, ot teacher	9.2
		Other	16.4
Educational level		**Class**	
Less than junior high school	36.6		
Junior high school	23.7	Civilians	76.6
Above junior high school	39.7	Others[2)]	23.4

[1)] In 2009, the average exchange rate was US$1.00 = NT$32.33.
[2)] Others include leaders, nobles, warriors, wizards, and priests.

Respondents' awareness level of theoretical TEK

Respondents' awareness levels of theoretical TEK are shown in Table 3. Cronbach's α of 0.95 reveals the excellent internal consistency of the questionnaire. The overall mean of the respondents' awareness level of theoretical TEK was 4.009, and as the questionnaire adopted a 6-point scale with no intermediate option, a result of ≥ 4 indicates that respondents tended to "somewhat agree" with the theoretical TEK description of Table 1. These interviewees had a positive awareness level of theoretical TEK.

In terms of plant knowledge, in addition to knowing the growth region (4.003), the means of respondents' awareness levels of plant usages (4.328), collection season (4.093), and edibility (4.394) were all higher than the overall average (4.009). This revealed that respondents had a higher level of plant knowledge. As for wildlife knowledge, the means of the respondents' awareness levels of wildlife distribution (3.808), breeding seasons (3.513), population forecasts (3.121), how to hunt animals (3.696), and traditional hunting ranges (3.786) were all lower than the overall average. This revealed the respondents had a lower level of wildlife knowledge. As for inheritance knowledge, it was noteworthy that the mean of those who regularly taught children TEK (3.726) was lower than the total average mean of theoretical TEK, indicating that the transmission rate of TEK was low.

Characteristics influencing respondents' awareness of theoretical TEK

An ANOVA/t-test was used to test whether socioeconomic characteristics had a significant impact on respondents' awareness of theoretical TEK. Results are shown in Table 3. We found that gender, age, educational level, income, occupation, and class all had significant influences on respondents' awareness level of theoretical TEK. Average theoretical TEK levels as influenced by different socioeconomic characteristics are shown in Table 4.

Table 3. Results of an ANOVA/*t*-test between respondents' awareness levels of theoretical traditional ecological knowledge (TEK) and socioeconomic characteristics

Item[a]	Mean[b]	Age		Gender		Education level		Income		Occupation		Class	
		F	*p*[c]	*t*	*p*[c]	*F*	*p*[c]	*t*	*p*[c]	*F*	*p*[c]	*t*	*p*[c]
A1	4.328	32.42	0.000**	4.409	0.000**	15.477	0.000**	3.011	0.003**	8.135	0.000**	-3.361	0.001**
A2	4.093	33.74	0.000**	3.769	0.000**	18.013	0.000**	3.415	0.001**	8.698	0.000**	-3.638	0.000**
A3	4.003	30.81	0.000**	4.804	0.000**	18.938	0.000**	3.181	0.002**	8.014	0.000**	-3.813	0.000**
A4	4.394	33.98	0.000**	4.693	0.000**	23.904	0.000**	2.853	0.005**	9.872	0.000**	-3.235	0.001**
A5	3.808	19.38	0.000**	7.239	0.000**	10.099	0.000**	1.434	0.152	8.035	0.000**	-3.725	0.000**
A6	3.513	14.13	0.000**	7.655	0.000**	3.973	0.002**	0.587	0.558	5.957	0.000**	-4.328	0.000**
A7	3.121	6.80	0.000**	6.915	0.000**	2.582	0.077	0.358	0.72	7.771	0.000**	-2.668	0.008**
A8	3.696	5.10	0.000**	11.873	0.000**	2.258	0.106	-0.54	0.59	5.523	0.000**	-3.589	0.000**
A9	3.786	12.15	0.000**	8.642	0.000**	4.135	0.017*	0.454	0.65	4.88	0.000**	-5.61	0.000**
A10	3.658	13.73	0.000**	5.693	0.000**	8.603	0.000**	1.179	0.239	2.93	0.0131*	-5	0.000**
A11	4.082	8.72	0.000**	6.108	0.000**	9.108	0.000**	1.339	0.181	2.445	0.034*	-4.269	0.000**
A12	3.924	14.92	0.000**	6.019	0.000**	6.268	0.002**	0.92	0.358	3.894	0.002**	-4.609	0.000**
A13	4.992	21.64	0.000**	2.081	0.000**	20.013	0.000**	3.342	0.001**	7.512	0.000**	-4.225	0.000**
A14	4.26	11.13	0.000**	3.802	0.000**	5.901	0.003**	2.816	0.005**	3.225	0.007**	-4.31	0.000**
A15	3.865	10.70	0.000**	4.339	0.000**	10.961	0.000**	1.526	0.128	2.097	0.065	-4.663	0.000**
A16	4.741	7.35	0.000**	2.445	0.015*	4.952	0.008**	2.091	0.037*	7.671	0.000**	-3.164	0.002**
A17	3.726	8.90	0.000**	2.911	0.004**	7.943	0.000**	1.167	0.244	1.89	0.095	-2.922	0.004**

a: The content of each item is shown in Table 3; b: Respondents' average awareness level of theoretical TEK; c: * $p < 0.05$, ** $p < 0.01$.

Table 4. Average awareness levels of theoretical knowledge by different socioeconomic characteristics

Item	mean	Item	mean
Gender		**Personal monthly income (NT$)[1)]**	
Male	4.3714	< 20,000	4.3714
Female	3.6184	≥ 20,001	3.6184
Age (yr)		**Occupation**	
20~29	3.3009	Farmer	4.4260
30~39	3.5623	Self-employed	3.9543
40~49	3.969	Unemployed	4.0229
50~59	4.3777	Laborer	3.5882
> 60	4.669	Military, civil servant, or teacher	3.8971
		Other	3.6928
Educational level		**Class**	
Less than junior high school	4.3170		
Junior high school	3.9441	Civilians	3.8627
Above junior high school	3.7535	Others[1)]	4.4809

[1)] See footnotes to Table 2.

In terms of gender, we found that male respondents had a higher awareness level of theoretical TEK than female respondents for all questions, and there was a significant difference between males and females. The average male's theoretical TEK was 4.3714, higher than that of females (3.6184). In terms of age, each theoretical TEK question also yielded a significant difference in the results. In particular, average theoretical TEK increased with age. The lowest theoretical TEK was in the 20~29-yr age group, with an average of 3.3009; the highest theoretical TEK was in the 60-yr age group, with an average of 4.669. In terms of educational level, apart from questions about population forecasts and how to hunt animals, all other questions yielded a significantly different result under different educational levels. There was a negative correlation between educational level and theoretical TEK. Respondents whose highest educational level was elementary schooling had the highest theoretical TEK with an average of 4.317; those who had graduated from junior high school had an average of 3.9441; and those who had graduated from senior high school or above had the lowest average at 3.7535. In terms of respondents' income, there was no relation to wildlife (A5~A9) or land (A10~A11), but there was a significant difference for other theoretical TEK questions. Respondents who had a personal monthly income of ≤ NT$20,000 had an average theoretical TEK of 4.3174, which was higher than those with a personal monthly income > NT$20,000, who had an average theoretical TEK of 3.6184. In terms of occupation, there were significant differences in each item of theoretical TEK. Those engaged in farming had the highest average at 4.426, while those that were self-employed had the lowest average at 3.5882. As to the respondents' class, there was a significant difference between civilians and non-civilians in all theoretical TEK questions. Non-civilians had a higher average mean at 4.4809 than civilians, who had an average of 3.8627.

Application of TEK to natural resources co-management with aborigines has recently become a policy trend. It is therefore necessary to know how TEK can contribute to natural resource management. Quantitative analyses in this study showed that most socioeconomic factors had a significant impact on respondents' awareness of theoretical TEK, which past qualitative analyses did not find. The variance of theoretical TEK implies 2 important things. One is that not everyone has the same theoretical TEK, especially with respect to age. The oldest segment of the population had the highest level of theoretical TEK. This awareness decreased with a younger age. The amount of theoretical TEK lost between generations is a serious concern. In addition, we should be concerned about the phenomenon of a decrease in knowledge transfer through inheritance. Urgent action is needed to record and facilitate its transmission.

The other implication relates to the social role of the participant. Kabeer (1997) suggested that gender relations, like all social relations, are multifaceted: they embody ideas, values, and identities; allocate labor between different tasks, activities, and domains; determine the distribution of resources; and assign authority, agency, and decision-making power. Agarwal (2001) indicated that resource management should consider the social inequality of participants to avoid an inequitable distribution of resources. After the *Ordinance for Natural Resources Co-management in Indigenous Peoples' Areas* was passed in 2007, many organizations set up co-management commissions for resource management. Aboriginal representatives on these co-management commissions will help determine resource allocation. Therefore, electing suitable aboriginal representatives from populations with unequal TEK is an interesting research question that may warrant future attention.

Respondents' practical TEK

The questionnaire listed 29 plants and 11 animals that interviewees had earlier identified. About 30% of the respondents used neither plants nor animals. Of the 29 plants, the main use was for food (27), and also for tools (13), construction (11), fuel (9), business (3), and medicine (3). In total, 224 of the respondents used plants, and more than half of these respondents used *Crassocephalum crepidioides* (87.1%), *Zanthoxylum ailanthoides* (86.2%), *Alpinia zerumbet* (85.3%), *Solanum americanum* (82.6%), *Pseudodrynaria coronans* (69.6%), *Pterocypsela indica* (68.8%), and *Trichodesma calycosum* (67.9%) for food. *Fraxinus griffithii* (26.3%), *Macaranga tanarius* (19.6%), *Machilus japonica* (18.3%), *Lagerstroemia subcostata* (16.1%), *Trema orientalis* (12.1%), and *Ficus irisana* (12.1%) were used for fuel and construction. *Alpinia zerumbet*, *Pseudodrynaria coronans*, *Hibiscus taiwanensis*, and *Arcea catechu* were used for tools. *Pseudodrynaria coronans*, *Solanum americanum*, and *Calamus formosanus* could be used for business, but this was not their main use. In terms of collection frequency, 96% of the respondents who used plants collected them 1~3 times a month. As for time required for 1 round trip, 48% of users required 1 d, 31% needed half a day, and 21% only required 1~2 h.

In the survey of animals, all 11 species could be used to meet personal and festival needs. Species such as wild boars, flying squirrels, birds, muntjacs, rabbits, and civet cats could also be used for business. In terms of the number of users, 113 of the respondents used animals. The most frequently used species were flying squirrels (95.6%), muntjacs (82.3%), and wild boars (75.2%), followed by serows (44.2%), civet cats (37.2%), and voles (34.5%). Least used were sambars (27.4%), rabbits (23%), pheasants (23%), birds (15%), and snakes (10.6%). In terms of collection frequency, 94% of users who hunted did this 1~3 times a month. As for the time required for 1 return hunting trip, 73% of users required 1 d, 18% of users spent 2~3 d, and 9% of users needed half a day.

Since the late stage of the Japanese occupation period, indigenous production modes have rapidly shifted from the traditional practice of slash-and-burn rice farming to the cultivation of cash crops and work in urban factories (Huang 1986). According to our investigation of practical TEK, 30% of respondents never used animals or plants. If flora and fauna were used, this was mainly for personal use, not for their main source of income. In addition, we found that since most users whose collected plants or hunted animals 1~3 times per month, there was no intensive use of these resources. This suggests that the Taiwanese aborigine lifestyle is no longer wholly dependent on forest resources.

Characteristics influencing respondents' practical TEK

To estimate whether gender and other socioeconomic factors influenced respondents' practical TEK, we added up the species of plant and animals used to indicate respondents' practical TEK. People who gathered plants from the forest on average collected 8.6 species each. Those who used animals on average hunted 4.68 species each. The average number of species used according to different socioeconomic characteristics is shown in Table 5. The socioeconomic impact assessment

Table 5. Mean number of species of plants and animals used by different socioeconomic characteristics

Item	mean[a]	mean[b]	Item	mean[a]	mean[b]
Gender			**Income (NT$)**[1)]		
Male	8.8	4.6	< 20,000	8.2	4.5
Female	8.3	4.7	≥ 20,001	9.8	4.9
Age (yr)			**Occupation**		
20~29	6.7	4.6	Farmer	9	4.0
30~39	8.2	4.4	Self-employed	8.5	3.6
40~49	8.0	5.3	Unemployed	8.6	5.2
50~59	9.7	4.3	Laborer	7.2	5.2
> 60	9.1	4	Military, civil servant, or teacher	11.4	5.0
			Other	7.4	5.1
Educational level			**Class**		
Less than junior high school	8.4	4.1			
Junior high school	9.7	5.6	Civilians	8.4	4.8
Above junior high school	8.2	4.4	Others[1)]	9.1	4.4

a: Mean number of species of plants used; b: Mean number of species of animals used.
[1)] See footnotes to Table 2.

of practical TEK is shown in Table 6. Although educational level had a significant impact on the number of animals used, no other factors had an influence on plants and animals used. The respondents who had graduated from junior high school hunted 5.60 species on average, which was higher than the total average of 4.68 species. Meanwhile, average numbers of species hunted at other educational levels were lower than the total average.

This study found that socioeconomic factors rarely affected respondents' practical TEK, but had a significant influence on theoretical TEK. However, an investigation solely focused on the theoretical or practical aspects of TEK would not be sufficient to portray the concept of TEK as a whole. This highlights the complexity of TEK, which is a cumulative body of knowledge, practices, and beliefs. It is therefore necessary to investigate

Table 6. Results of an ANOVA/*t*-test between respondents' practical traditional ecological knowledge (TEK) and socioeconomic characteristics

Item	Used plants ($n = 224^a$)		Used animals ($n = 113^b$)	
	t/*F*	*p* value	*t*/*F*	*p* value
Gender	0.679	0.498	-0.163	0.87
Age	1.916	0.109	0.961	0.432
Educational level	1.609	0.202	3.102	0.049*
Personal monthly income	-1.835	0.07	-0.774	0.441
Occupation	-0.918	0.36	0.928	0.356
Class	1.79	0.116	1.477	0.216

a, b: We only estimated people who used plants or animals, and excluded non-users.
* $p < 0.05$.

and analyze different aspects of TEK to better understand its true essence.

The relation between theoretical and practical knowledge

Many studies have shown that theoretical ethnobotanical knowledge and uses of plants are positively correlated. People who have higher ethnobotanical knowledge can use more plant species and for more ends than people who have less ethnobotanical knowledge. Or it may be the other way around, with those who use more plants interacting more with the environment, thus increasing their ethnobotanical knowledge (Reyes-Garcia et al. 2005). Researchers (Byg and Balslev 2001, Ladio and Lozada 2004) used a correlation analysis to estimate whether the 2 variables had a positive relation. Following their example, we summed up respondents' awareness level of theoretical TEK about plants (A1~A4) and animals (A5~A9), then estimated their relation to species of plants and animals used, respectively. We found a positive and statistically significant correlation between theoretical TEK of plants and the plants used (correlation coefficient = 0.179, $p < 0.01$, $n = 224$). On the other hand, although there was a positive correlation between theoretical TEK of animals and the species used, the correlation was not significant (correlation coefficient = 0.131, $p = 0.172$, $n = 113$). Results are shown in Table 7. Ladio and Lozada (2004) argued that discrepancies between theoretical and practical knowledge stem from changes in people's way of life. Reyes-Garcia et al. (2005) suggested that when indigenous people become more integrated into the market economy, they stop using plants. In the short term, this will not affect the amount of ethnobotanical knowledge held. This may help explain why theoretical TEK of animals had no significant relation to animals used by Paiwan hunters from Jialan Village.

Table 7. Results of Pearson's correlation analysis between theoretical and practical traditional ecological knowledge (TEK)

Item	Coefficient[a]	p value	N[b]
Plants	0.179	0.006*	224
Animals	0.131	0.172	113

a: We summed up the respondents' awareness level of A1~A4/(A5~A9) as theoretical TEK and the respondents' used species of plants/(animals) as practical TEK, then estimated the correlation coefficient of theoretical and practical TEK about plants/(animals); b: N = number of users, for which we only estimated people who used plants or animals, and excluded non-users.

* $p < 0.05$.

CONCLUSIONS

TEK is a cumulative and dynamic body of knowledge. It provides a historical understanding of environmental change (Menzies 2006). The composition of TEK is complex, so it is difficult to capture the entire essence of TEK. In this study, we focused on identifying the contents of theoretical and practical TEK of Paiwan people in Jialan village, by revealing influencing factors and the relationship between theoretical and practical TEK.

Results showed that respondents had a positive awareness level of theoretical TEK. However, cognitive ability was not homogeneous across individuals: gender, age, income, education level, and class all had a significant influence on the awareness level of theoretical TEK. It was noteworthy that the younger generation had a lower level of theoretical TEK, which may reflect an ongoing loss of theoretical TEK in youth. In addition, we found that 30% of the respondents did not use flora or fauna. Those who did mainly used them for personal purposes rather than for business. The average frequency of use was 1~3 times a month, which reflects that respondents were no longer wholly dependent on forest resources for their livelihoods. Finally, we found a positive and statistically significant correlation between theoretical TEK of plants and the plants used, which is in line with theoretical expectations.

From the quantitative analysis above, we found a difference in awareness between the theoretical and practical aspects of TEK and a diminishing interaction between people and their environment. To successfully incorporate TEK into natural resource management, management authorities should be concerned about the gradual loss of TEK, and we suggest that authorities should actively increase the investigation of TEK and documentation through written records, which is vital before it is lost forever. TEK is intangible and holistic, so developing methods of TEK preservation, translation, and application is a challenge for future research.

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