What the Locals Know: Comparing Traditional and Scientific Knowledge of Megapodes in Melanesia

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Many conservation projects occur where the local people have extensive traditional ecological knowledge (TEK); yet most rely solely on scientific ecological knowledge (SEK). In many cases, a more constructive approach would be to integrate the two knowledge systems to gain reliable knowledge for better management. In order to promote this, the TEK of two peoples in Melanesia regarding four species of megapodes (Megapodiidae) was surveyed and compared with SEK. Results show TEK from observations of megapodes is reliable knowledge, being consistent with SEK, varying little within and among social groups and enabling people to answer most of the questions asked. TEK from interpreting observations was less reliable. Reliability of TEK varied according to the way in which the sexes and peoples interact with megapodes: for areas where groups interact most with megapodes, their knowledge is most reliable and vice versa. Successful integration of the two knowledge systems may improve the conservation of both biological and cultural diversity, while empowering indigenous peoples.

Introduction

Conservation biologists in Melanesia often work on a poorly known biota without time for long-term research projects. The indigenous peoples at project sites invariably have long histories and extensive traditional ecological knowledge (TEK). In this context, for conservation purposes, it would make sense to integrate the TEK of indigenous peoples and the scientific ecological knowledge (SEK) of the outsiders who work with them on conservation projects.

It is surprising that few attempts have been made to integrate TEK and SEK in Melanesia, where 97 per cent of land is under customary land tenure that precludes the establishment of large state-owned national parks (King, 1989), and where most decisions on land-use practices are made at the family level (Marat, 1991). Furthermore, despite the wealth of TEK that has underpinned indigenous peoples' interactions with nature for millennia, well-funded science-based conservation projects in Melanesia do not incorporate TEK and fail to protect 'critical' species (e.g. Johnson et al, 2004), fail to meet the expectations of indigenous peoples (e.g. West, 2006) or simply fail completely (e.g. McCallum and Sekhran, 1997).

Understanding of what parts of TEK are reliable is needed for two reasons. First, if indigenous peoples are to continue to benefit from their interactions with nature, they need to base their decisions on reliable knowledge (Moller et al, 2004) and some TEK is unreliable. For example, tinoni Simbo (people from Simbo Island, Solomon Islands; Hocart, 1922) believe that megapodes lay 700 to 1000 eggs per year (see Table 10.2), an overestimate of one to two orders of magnitude (Jones et al, 1995). This TEK may have been adequate to ensure sustainable harvests with a small human population on Simbo Island; but with rapid population growth and increasing harvests of eggs (Sinclair, 1999), it may promote unsustainable harvesting and extirpation of megapodes, as has occurred on numerous other Pacific Islands (Steadman, 2006). Second, understanding what parts of TEK are reliable is needed to promote its integration with SEK by sceptical or ill-informed conservation biologists. Indentifying where TEK is reliable will help conservation biologists do a better job in a more cost-effective way, and identifying where it is unreliable will suggest areas where their methods and SEK can be of most assistance to indigenous peoples for resource management. Although informal methods for 'screening' informants for reliability have been used (e.g. Johannes, 1989), few studies formally test the reliability of TEK, and this is a shortcoming of much literature on TEK (Johannes, 1993). This chapter aims to promote the integration of the two knowledge systems and was undertaken by testing the reliability of TEK for four species of megapodes (Megapodiidae) at two sites in Melanesia.

Defining reliability of traditional ecological knowledge

Two events led to the present chapter. The first occurred while explaining a research proposal to local Pawaia (people from the Pio-Tura region of Papua New Guinea; Ellis, 2002) assistants. Whenever a research question was explained (e.g. 'How many eggs does a megapode lay in a year?'), the assistants immediately gave a seemingly definitive answer (e.g. '12 to 14 eggs per year'). Two things were notable: first, the men were confident about their answers; second, their answers were consistent with SEK at that time.

The second event occurred when a Pawaia assistant explained how Superb Fruit-doves *Ptilinopus superbus* abandon their nests when repeatedly disturbed, build another nest nearby and then carry their eggs to the new nest. When asked where he had seen this behaviour, the assistant replied he had never actually seen it, but this was the best explanation for what he had observed. Again, two things were notable: first, this knowledge was unreliable, although it may have been true; second, it was promoted with the same certitude as a direct observation. In the authors' subsequent work with indigenous peoples, different weights were placed on the reliability of TEK derived from direct observations and that derived from interpreting such observations, as has been done by other researchers (e.g. Ferguson and Messier, 1997; Usher, 2000; Newman and Moller, 2004). This 'field filter' applied to TEK led the authors to develop hypotheses and generate predictions about the reliability of the TEK of megapodes and then test these once some reliable SEK had been gained for the same birds.

It is difficult to define a metric that gauges the comparative reliability of knowledge (Scranton, 2000) because reliability itself is subjective. For conservation and management, an operationally relevant measure of reliability is required that is sufficient to base decisions about resource management now and in the future. In this chapter, reliability of TEK is defined in terms of certainty (i.e. proportion of answers other than 'I do not know'), precision (i.e. proportion of similar answers within and among sex and age groups) and accuracy (i.e. level of consistency between TEK and SEK).

Indigenous peoples and megapodes in Melanesia

Megapodes are a socio-culturally, historically and economically important family of birds for many peoples in the Indo-Pacific. Their eggs are an abundant and predictable resource and are heavily harvested (e.g. Hide et al, 1984; Argeloo and Dekker, 1996; Sinclair, 2001a). On Simbo Island, Melanesian Megapodes *Megapodius eremita* lay eggs in burrows at geothermal nesting fields (Sibley, 1946). In the Crater Mountain Wildlife Management Area, Papua New Guinea, three species of megapodes are sympatric in lower montane rainforest: New Guinea Megapodes *Megapodius decollatus*, Brown-collared Talegallas *Talegalla jobiensis* and Wattled Brush-turkeys *Aepypodius arfakianus* (Sinclair, 2001b). These species lay eggs in incubation mounds that they build by raking together organic material on the forest floor (Sinclair, 2002). Brush-turkeys are sexually dimorphic and uncommon (Jones et al, 1995); the male alone builds and maintains the mound, while the female visits it only to copulate and lay (Sinclair, 2000). Talegallas are sexually monomorphic and are known to share mounds with other species (Dwyer, 1981; Hide et al, 1984; Sinclair, 2002). *Megapodius* species are sexually monomorphic and socially monogamous, occur throughout the range of the family and use all of the heat sources and types of incubation sites described for the family (Jones et al, 1995): more than one pair of New Guinea Megapodes use some mounds (Sinclair, 2000) and hundreds or thousands of Melanesian Megapodes may lay in colonial-nesting fields (Broome et al, 1984).

The Pawaia people have influences and relations with groups from both the highlands and southern coast of Papua New Guinea (Ellis and West, 2004) and did not receive regular visits from outsiders until the 1960s and 1970s (Warrillow, 1983). There were 1086 Pawaia people in 1999 (Ellis, 2002), with 760 people in 130 households in Haia village (Johnson et al, 2004), although family groups generally move regularly to dwellings dispersed around the forest (Ellis, 2002). Pawaia people practise diverse subsistence activities, with sago palm *Metroxylon sagu* being their staple food together with plantains *Musa* spp., sweet potato *Ipomoea batatas* and aibika *Abelmoschus manihot* (Toft, 1983). They also harvest a wide variety of animals from the forest (Toft, 1983; Hide et al, 1984; Mack and West, 2005). Pawaia people were paid assistants and porters in this work, so were informers and not partners in this research, and the work with them on TEK was retrospective, undertaken after research into megapodes had been completed.

Tinoni Simbo of the Solomon Islands have had over 200 years of sustained contact with Europeans (Bennett, 1986) and over the past 100 years have undertaken dramatic and repeated socio-cultural and economic changes (Dureau, 1998). The island had a resident population of 1560 people in 273 households grouped in about 40 hamlets in 1997 (unpublished data). The most common subsistence crops are cassava (*Manihot esculenta*), sweet potato and plantains. Tinoni Simbo regularly consume fish and megapode eggs, with wildlife, domestic chickens and pigs consumed only occasionally. Both land and sea resources are considered by tinoni Simbo to be overharvested (Sinclair, 1999). The work on Simbo Island was prospective in being at the start of a research project, and tinoni Simbo were partners rather than informers in this research; tinoni Simbo requested help to develop a sustainable harvesting plan for megapode eggs, a problem that their TEK alone had not been able to address to their satisfaction.

In this chapter, the TEK of the Pawaia people and tinoni Simbo regarding megapodes was used to test predictions from two hypotheses:

1 TEK from direct observations is reliable knowledge.
2 TEK from interpreting observations is unreliable knowledge.

The first hypothesis predicts that TEK from direct observations will be:

- widely known among indigenous people;
- consistent within and among sex and age groups; and
- similar to SEK.

Table 10.1 *Comparisons between traditional (TEK) and scientific ecological knowledge (SEK) of megapodes in Papua New Guinea*

Questions based on observations	*Answers from scientific ecological knowledge*	*Accuracy*
What colour are the eggs?	NGM and BCT red/brown; WBT white.[1, 2, 3]	92 (8)%
In what months are the eggs laid?	NGM all months; WBT and BCT March–November.[2, 4, 5]	100 (46)%
How many eggs are laid per year?	10–20 for all species.[3, 7, 6]	61 (51)%
Where are mounds located?	WBT steep sites and more shrubs; NGM and BCT by larger trees.[1, 2]	84 (9)%
Are mounds built in the same types of places?	NGM and BCT: yes; BCT and WBT: no; NGM and WBT: no.[1, 2]	68 (33)%
From what materials are mounds built?	WBT leaves and sticks; NGM and BCT: humus, soil, leaves, sticks.[2, 4]	94 (13)%
Do the ♂ & ♀ build mounds together?	NGM: yes; WBT: ♂ only; BCT: ?[2, 6, 8]	53 (52)%
Is there intra-specific sharing of mounds?	NGM: yes; WBT: no; BCT: ?[2,4,9]	53 (58)%
Is there inter-specific sharing of mounds?	NGM and BCT: yes; BCT and WBT: yes; NGM and WBT: no.[2, 4, 5, 10, 11]	58 (17)%
How many ♀♀ does the ♂ have?	NGM: one; WBT >1; BCT: ?[2, 3]	48 (63)%
How many ♂♂ does the ♀ have?	NGM: one; WBT >1; BCT: ?[2, 3]	50 (71)%
Do the ♂ & ♀ look the same?	NGM and BCT: yes; WBT: no.[2, 3]	60 (47)%
If not, how do the ♂ & ♀ differ?	WBT: ♂ larger with larger and brighter wattles.[2, 3, 6]	50 (80)%
	Overall	71 (30)%
Questions based on interpretations	*Interpretations from scientific ecological knowledge:*	*A, P, I*
Why do ♂ and ♀ NGM build mounds, but only ♂ WBT?	NGM socially monogamous; WBT polygyny and polyandry.[2, 3]	20, 20, 60 (83)%
Why do NGM and BCT call in the forest, but WBT do not?	NGM (and BCT?) socially monogamous and territorial; WBT not.[2]	13, 63, 25 (73)%
Why do WBT call from the mound, but NGM and BCT do not?	WBT call ♀♀; NGM (and BCT?) socially monogamous.[1, 2]	82, 0, 18 (63)%
Why do WBT bury eggs shallower than NGM and BCT?	Differences in thermal properties of mounds.[4]	33, 33, 33 (70)%
Why do ♂ & ♀ NGM look similar, but WBT do not?	NGM socially monogamous; WBT polygynous.[2, 3]	50, 50, 0 (93)%
Why are some NGM mounds large, but WBT always small?	NGM mounds used many years, lower organic content.[2, 4, 9]	28, 33, 39 (40)%
	Overall	38, 32, 30 (61)%

Notes: Pawaia people (n = 30) from Papua New Guinea were asked 'observation' questions separately for New Guinea Megapodes, *Megapodius decollatus* (NGM), Brown-collared Talegallas, *Talegalla jobiensis* (BCT) and Wattled Brush-turkeys, *Aepypodius arfakianus* (WBT) and 'interpretation' questions only once, making a total of 51 questions. The last column is the percentage accuracy of responses other than 'I do not know' (with the percentage who answered 'I do not know' in parentheses). Accuracy ('A') is consistency between the TEK of Pawaia people and SEK, while there were also plausible ('P') and implausible (I) alternatives for TEK based on interpretations. There was no significant difference in proportions of A, P and I for interpretations among older men, older women and younger men ($G_2 = 4.7$; $P = 0.32$). Sources for SEK are given in footnotes. Answers for the TEK of Pawaia people are given in Table 10.3.

Source: 1 Sinclair (2002); 2 Sinclair (2000); 3 Jones et al (1995, including citations); 4 Sinclair (2001b); 5 Hide et al (1984); 6 Coates (1985 and references therein); 7 J. Ross Sinclair (unpublished data); 8 Kloska and Nicolai (1988); 9 Rand and Gilliard (1967); 10 Dwyer (1981); 11 Gilliard and LeCroy (1966)

The second hypothesis yields predictions that are the inverse of the three points above. To test these predictions the results of oral questionnaires, semi-structured interviews and collaborative fieldwork (following Huntington, 2000; Fraser et al, 2006) were compared within and among social groups and with SEK.

Study sites

The first study site was Haia village (06° 42.5'S, 144° 59.8'E) in the Crater Mountain Wildlife Management Area, a 2600 square kilometre area of lowland and lower montane rainforest in the eastern highland region of Papua New Guinea. Megapode eggs are considered an important food source for Pawaia people (Hide et al, 1984), with the collection of eggs from incubation mounds widespread and megapodes being about 4 per cent of the individual animals killed by hunters in the area (Mack and West, 2005). The second site was Simbo Island (8° 17.5'S; 156° 0.5'E), Western Province, Solomon Islands. Most of the 14 square kilometre island is a matrix of gardens, coconut plantations and secondary regrowth, with isolated patches of lowland rainforest and about 2.5 square kilometres of continuous forest surrounding the largest megapode field. Melanesian Megapodes are important in the history and culture of tinoni Simbo (e.g. Hocart, 1922), and according to them became an important part of the cash economy during the 1960s and 1970s, coinciding with a perception that the harvest of megapode eggs was declining (Sinclair, 1999). Tinoni Simbo harvest megapode eggs from natural burrows and shade houses – expanded burrows with roofs built and managed to maximize their harvest of eggs (Sinclair, 2001a). About 65 per cent of families on the island have rights to harvest megapode eggs (unpublished data).

Recording traditional ecological knowledge (TEK)

In Haia village, a random selection of older women, older men and younger men (ages based on marital status since individuals did not know their birth dates) from 12 clans were given oral questionnaires using a mixture of Tok Pisin, a version of Melanesian Pidgin English, and Tßehõe (by Muse Opiang, a native Tok Pisin speaker with some Tßehõe), the language of Pawaia people (Ellis, 2002). The questions listed in Table 10.1 were designed to elicit answers based on direct observations or interpretations of observations by Pawaia people, and because they could be compared to existing SEK.

On Simbo Island, semi-structured interviews were undertaken with nine local experts (six older men and three older women, aged 47 to 97 years old) chosen because they:

- had rights to collect megapode eggs;
- had more than 30 years of experience collecting megapode eggs; and
- were recognized locally as experts and as honest.

Table 10.2 *Comparisons between traditional (TEK) and scientific ecological knowledge (SEK) of megapodes in the Solomon Islands*

Questions about Melanesian Megapode	*Answers from traditional ecological knowledge of tinoni Simbo*	*Answers from scientific ecological knowledge*	*C*	*P (♀, ♂)*	*A*
Forage together?	In twos (7); groups (2)	Two (socially monogamous)[1, 2, 3]	9/9	3/3, 4/6	7/9
What are their predators?	Dogs (8); raptors (7); cats (3); varanids (2)	Mammals, raptors, varanids[1, 2, 3, 4]	9/9	3/3, 6/6	9/9
When are they vulnerable?	Chicks (4); adults in burrows (3)	At hatching, <4 weeks' old[1, 4]	5/5	1/1, 4/4	4/5
What is eaten?	Nuts (8); worms (6); fruits (2)	Fruits, seeds and arthropods[2, 3]	9/9	3/3, 6/6	9/9
In what areas are they common?	Primary forest (7); secondary forest (1); gardens (1)	Primary and secondary forest[1, 5]	9/9	3/3, 4/6	8/9
In what areas are they uncommon?	Gardens (5); coconuts (3); secondary forest (2); do not know (2)	Gardens and disturbed areas[1, 5]	7/9	3/3, 4/4	7/7
How long lived are they?	Do not know (8)	5–15 years[2]	0/8	–	–
Do ♂ & ♀ differ?	Same (3); ♂ in gardens (2); ♂ more red skin (2)	Monomorphic[2]	9/9	3/3, 3/6	3/9
Do they lay outside the volcano?	In dead roots (6); on ground (5); piles of leaves (2)	Dead roots, piles of leaves[1, 3, 6]	8/8	3/3, 5/5	8/8
Are there egg seasons?	Yes (8): more May–December (7); less December–May (8)	More June–December; less January–May[1]	8/8	2/2, 6/6	8/8
How does one know the age of eggs?	Candling (5); flaking pigment (5); tapping (5)	Size of embryo by candling[7]	7/7	2/2, 5/5	7/7
How long is incubation?	2–4 weeks (3); 3 months (3); do not know (2)	45–70 days[2, 4]	6/8	2/3, 1/3	0/6
Are the eggs buried at the same depth?	In three layers (4); layers (2); bottom of burrow (1)	Layers[2, 3]	9/9	3/3, 6/6	9/9
What eats the eggs?	Varanids (9); pigs (1); snakes and cats (1)	Varanids, snakes, dogs and pigs[2, 3]	9/9	3/3, 6/6	9/9
How many eggs are laid per annum?	700 (1); 1000 (1); do not know (5)	Circa 10–30[2]	2/7	2/2, –	0/2
How many birds dig and lay?	1 (5); 1–2 (2)	1[1, 2, 3, 5]	7/7	1/2, 3/5	5/7
How often are eggs laid?	3 per day (3); 2 per day (2); 1 per day (2)	Circa every 2–15 days[2, 3]	7/7	2/2, 5/5	0/7
		Overall (%)	88	95, 87	78

Notes: Nine megapode experts from Simbo Island, Solomon Islands, were interviewed about their TEK of the Melanesian Megapode *Megapodius eremita*. Certainty ('C') is the number who gave answers other than 'I do not know'; precision ('P') is the number of similar answers within sex groups; and accuracy ('A') is the number of responses consistent with SEK. The figures in parentheses are the number of responses, with some interviewees giving more than one answer. Sources for SEK are given in footnotes.

Source: 1 J. Ross Sinclair (unpublished data); 2 Jones et al (1995, including citations); 3 Kisokau (1976, 1991); 4 Sinclair (2001a); 5 Broome et al (1984); 6 Sibley (1946); 7 Wong (1998)

Table 10.3 *Traditional ecological knowledge (TEK) of Pawaia people regarding megapodes*

	New Guinea Megapode	*Wattled Brush-turkey*	*Brown-collared Talegalla*
TEK based on observations			
Egg colour (red : white)	93% : 4%, n = 27(2)	7% : 93%, n = 28(2)	89% : 11%, n = 28(2)
Months eggs laid	4–12, 100%, n = 19(11)	4–6, 100%, n = 16(14)	6–12, 100%, n = 15(15)
Clutch size:	n = 13(13)	n = 14(13))	n = 14(13)
<10	41%	14%	29%
10–30	58%	79%	57%
>30	1%	1%	14%
Location of mounds:	n = 26(3)	n = 26(2)	n = 25(4)
Beside large trees	73%	19%	80%
On steep slopes	31%	58%	28%
With dense shrubs	4%	12%	4%
Other places	12%	35%	28%
Mounds in similar sites	= WBT, 78%, n = 9(1)	= BCT, 71%, n = 9(1)	= NGM, 71%, n = 7(1)
Materials in mounds:	n = 27(2)	n = 27(2)	n = 27(2)
'Dry' leaves	100%	100%	100%
'New' leaves	4%	37%	4%
Sticks	70%	33%	70%
Soil	19%	15%	19%
Stones	4%	0%	11%
♂ & ♀ build mound	90%, n = 20(0)	78%, n = 23(0)	95%, n = 22(0)
Sex that builds mound	♂ 100%, n = 2(0)	♂ 100%, n = 6(0)	♀ 100%, n = 1(0)
Intra-species mound sharing	63%, n = 19(10)	40%, n = 20(8)	50%, n = 20(8)
Inter-species mound sharing	And WBT, 29%, n = 26(2)	And BCT, 27%, n = 26(4)	And NGM, 76%, n = 25(2)
♂ monogamy : polygyny	50% : 50%, n = 16(13)	53% : 47%, n = 17(12)	58% : 42%, n = 19(10)
♀ monogamy : polyandry	54% : 46%, n = 13(16)	58% : 42%, n = 12(17)	55% : 45%, n = 11(18)
Sexually monomorphic	65%, n = 17	50%, n = 17	59%, n = 14
How the sexes differ:	n = 5	n = 6	n = 8
♀ bigger	20%	60%	25%
♂ bigger	60%	20%	12%
♂ has comb (wattles)	20%	20%	25%
♂ red/featherless neck	0%	0%	38%

TEK based on interpretations

Why do ♂ & ♀ NGM build mounds but only ♂ WBT? No agreement (0%, n = 5).
Why do NGM and BCT call in the forest but WBT do not? NGM and BCT call for assistance from partner (38%, n = 8); WBT only call when breeding (20%).
Why do WBT call from the mound but NGM and BCT do not? WBT male calls female to lay (53%, n = 12); BCT and NGM sexes always together, so ♂ does not call ♀ (27%).
Why do WBT bury eggs shallower than NGM and BCT? WBT shallower as egg shell thinner (20%, n = 10); NGM and BCT mound bigger, so eggs deeper (20%).
Why do ♂ & ♀ NGM look similar, but WBT do not? No agreement (0%, n = 1).
Why are some NGM mounds large, but WBT always small? NGM and BCT build mounds together, so larger, whereas WBT build alone, so smaller (23%, n = 19), NGM mounds used for many years, so larger (18%);
WBT used only one year, so smaller (18%) because WBT are smaller birds (18%).

Notes: NGM = New Guinea Megapodes, *Megapodius decollatus*; BCT = Brown-collared Talegallas, *Talegalla jobiensis*; WBT = Wattled Brush-turkeys, *Aepypodius arfakianus*. Sample size is the number of people who answered the question, with the additional number who said 'I do not know' in parentheses. Values are the percentage of those who answered that gave each answer: higher values mean less variation and therefore higher precision. Percentages do not always sum to 100% as multiple answers were sometimes given. See Table 10.1 for the questions asked and answers according to scientific ecological knowledge.

The questions listed in Table 10.2 were asked in either Pijin, a version of Melanesian Pidgin English, or English (by J. Ross Sinclair) and then translated into Simbo (by native Simbo speaker Lorima Tuke).

TEK of megapodes in Papua New Guinea: Responses to oral questionnaires

The oral questionnaires given to Pawaia people revealed that they have a detailed understanding of many aspects of megapode behaviour and ecology (summarized in Table 10.3). For example, most people stated that Brush-turkey eggs are white, whereas those of the other two species are reddish brown. The three species are said to lay about 12 to 14 eggs per year, with most eggs found during the *Pandanus* spp. fruiting season (April to December). Mounds of New Guinea Megapodes and Talegallas are said to be most often located at the base of large trees and sometimes on steep slopes, whereas those of Brush-turkeys are usually on steep slopes and sometimes at the base of large trees. Despite microhabitat differences, mounds of the three species were said to be found in similar types of habitat and all contain 'dry' leaves, although New Guinea Megapode and Talegalla mounds also contain sticks and soil. Most people say that for all species, both sexes build the mound; New Guinea Megapodes and Talegallas are sexually monomorphic; and intra-specific sharing of mounds occurs in New Guinea Megapodes.

The reliability of Pawaia TEK based on observations

Pawaia people have reliable TEK of the natural history of megapodes; their responses indicated high levels of certainty (78 per cent), precision (74 per cent) and accuracy (71 per cent) (see Table 10.4). Pawaia people were precise and accurate in their answers both within and among sex and age groups, and there were no significant differences in these. There were, however, significant differences in certainty between sex and age groups: older men (87 per cent) answered significantly more questions than did older women (70 per cent) or younger men (75 per cent) (see Table 10.4).

Certainty and precision among Pawaia people, and accuracy between TEK and SEK, were generally highest for knowledge about eggs and mounds and lowest for knowledge about birds and their behaviour (see Tables 10.1 and 10.3). For example, certainty, precision and accuracy were all high for egg colour, the months in which eggs are laid and the location of mounds, but low for the mating systems of species and how the sexes differ.

The reliability of Pawaia TEK based on interpreting observations

In interpreting the observed behaviour and ecology of megapodes, Pawaia people do not have reliable TEK; their responses indicated low levels of certainty (31 per cent), precision (28 per cent) and accuracy (38 per cent) (see

Table 10.4 *The reliability of traditional ecological knowledge (TEK)*

TEK based on observations	*n*	*N*	*Certainty*	*Precision*	*Accuracy*
Pawaia	30	1015	78%	74%	71%
Older ♂	11	368	87 (28–100)%	71%	73 (52–100)%
Older ♀	10	335	70 (0–88)%[1]	76%	70 (0–90)%
Young ♂	9	312	75 (37–82)%[1]	74%	71 (52–83)%
			$G_2 = 53.2^{***}$	$G_2 = 1.3$, ns	$G_2 = 1.7$, ns
Simbo	9	137	88%	72%	78%
Older ♂	6	93	85 (80–94)%	87%	81 (62–92)%
Older ♀	3	44	93 (88–100)%	95%	73 (69–86)%
			$G_1 = 2.0$, ns	$G_1 = 3.2$, ns	$G_1 = 0.3$, ns
TEK based on interpretations	*n*	*N*	*Certainty*	*Precision*	*Accuracy*
Pawaia	30	180	31%	28%	38%
Older ♂	11	66	42 (0–67)%	25%	43 (0–75)%
Older ♀	10	60	20 (0–50)%[1]	35%	50 (0–100)%
Young ♂	9	54	24 (0–67)%[1]	13%	15 (0–33)%
			$G_2 = 8.4^{*}$	$G_2 = 2.3$, ns	$G_2 = 2.1$, ns
TEK in a practical application	*n*	*N*	*Certainty*	*Precision*	*Accuracy*
Pawaia ♂	12	52	100%	95%	90%
Simbo	30	15	100%	77%	80%
♂	20	15	100%	75%	80 (33–93)%
♀	10	15	100%	80%	78 (53–100)%
			–	$G_1 = 1.4$, ns	$G_1 = 1.0$, ns

Notes: Pawaia people of Papua New Guinea and tinoni Simbo of the Solomon Islands were asked about TEK:

- based on direct observations of megapodes;
- requiring interpretation of observations; and
- in a practical application.

Reliability is quantified in terms of certainty, precision and accuracy (see text for definitions). Sample sizes are the number of people interviewed (*n*) and total number of questions asked (*N*). Values are medians with the range in parentheses. Log-likelihood G-tests and unplanned tests of homogeneity of replicates ($\alpha = 0.05$ adjusted for the number of tests performed) were used to determine whether differences existed among social groups. There is a significant association between accuracy and type of Pawaia TEK, with that from observations (71%) significantly higher than that from interpretations (38%; $G_1 = 4.6^{*}$).

* $P < 0.05$; *** $P < 0.001$; ns $P > 0.05$.

1 Homogeneous set.

Table 10.4). Pawaia people of different sex and age groups were equally imprecise and inaccurate in interpreting observations (see Table 10.4). As with observational TEK, however, there were significant differences in certainty: older men (42 per cent) answered significantly more questions than did older women (20 per cent) or younger men (25 per cent) (see Table 10.4).

Certainty, precision and accuracy were low for all questions requiring interpretation of observations; no questions elicited responses for which a majority of those surveyed had some TEK, where the majority agreed on what TEK they had or where the majority of that TEK was consistent with SEK (see Tables 10.1 and 10.3). In general, the TEK of Pawaia people based on interpretations was split evenly among answers that were consistent with SEK, provided plausible alternative interpretations and provided implausible or false interpretations, with no significant differences among these (see Table 10.1).

The prediction that the TEK of Pawaia people derived from direct observations (71 per cent accuracy) would be closer to SEK than was TEK involving the interpretation of observations (38 per cent) (see Table 10.4) was supported.

TEK of megapodes on Simbo Island: Responses to semi-structured interviews

The semi-structured interviews with megapode experts on Simbo Island revealed that they have an extensive knowledge of megapode behaviour and ecology (summarized in Table 10.2). For example, according to tinoni Simbo, megapodes occur mostly in pairs, are found in all habitat types, although they are most common in mature forest or places where their food, the *Canarium indicum* and *C. Salomonens* nuts, is found, and are less common in gardens, coconut plantations and 'dry places' where there are few big trees. Megapodes are said to scratch in leaf litter for arthropods and fallen seeds, fruit and nuts, spoil gardens by digging in them and roost in trees from which they call throughout the night. They are said to dislike disturbance close to nesting fields, such as the clearing of bush, location of houses or presence of people.

According to tinoni Simbo, megapodes are most vulnerable to predators as chicks but are also vulnerable as adults when they dig burrows. One megapode is said to go to the field daily to lay 1 to 3 eggs in all months and between 300 to 1000 eggs per year. Monitor lizards, *Varanus indicus*, are said to dig into burrows and eat eggs, leaving a largely intact shell with only the top removed. This contrasts with the many small fragments left when an egg has hatched.

Eggs are said to take from two weeks to three months to incubate, and chicks are able to run and fly as soon as they hatch. Tinoni Simbo determine the stage of incubation by shinning a torch beam through the egg (or holding it up to the sun) – the size of the shadow indicating the size of the embryo, observing flaking of reddish pigment from the eggshell as it ages and a 'heavy' sound from tapping the egg indicating an embryo is present.

In the past, megapode burrows were said to be plentiful, so little effort was required to find eggs. The first shade house was said to have been built during the 1930s and these are used to mark an individual's harvesting area, increase the egg harvest, ensure the ground inside stays soft over the 'poor' season, concentrate eggs in one place, and increase the number of eggs laid because megapodes are said to like the conditions in shade houses.

The reliability of the TEK of tinoni Simbo based on observations

Tinoni Simbo have reliable TEK of megapodes based on direct observations given their high levels of certainty (88 per cent), precision (72 per cent) and accuracy (78 per cent) (see Tables 10.2 and 10.4). There was no significant difference in these scores between older women and older men (see Table 10.4).

Only four questions elicited responses of 'I do not know', with no one able to answer questions on the longevity of megapodes, and there was disagreement within sex groups for only five questions (see Table 10.2). Accuracy was low for four questions, with no consistency between TEK and SEK for the incubation period of eggs, the number of eggs laid per annum and the interval between laying of eggs (see Table 10.2). Questions for which certainty and accuracy were lower tended to be those for which repeat observations of birds or eggs are needed, whereas there seemed to be no pattern to the types of TEK for which precision was lower. For 7 of the 17 questions asked there was 100 per cent certainty, precision and accuracy, including the predators of megapodes and their eggs, megapode diet, seasonality of laying, where and how eggs are laid, and methods of determining the age of embryos (see Table 10.2).

The reliability of TEK in a practical application

The TEK of Pawaia people and tinoni Simbo was surveyed using oral questionnaires and semi-structured interviews, not the normal methods by which they transmit or express their TEK – TEK is transferred by experiential learning and participation (Huntington, 2000). Because of this, the reliability of TEK was also tested using collaborative fieldwork. We asked Pawaia assistants which species of megapode was using a mound when we first encountered the mound in fieldwork and asked tinoni Simbo whether a selection of eggs contained embryos. The mounds on Pawaia lands were subsequently excavated and assigned to species based on the size and colour of eggs (Jones et al, 1995) and the eggs on Simbo island were cooked and opened to look for embryos. Both cases confirmed observational TEK to be reliable in having high certainty (100 and 100 per cent for Pawaia people and tinoni Simbo, respectively), precision (95 and 77 per cent) and accuracy (90 and 80 per cent), and in the case of tinoni Simbo, where we tested for differences between the sexes, these responses were similar for men and woman (see Table 10.4).

The reliability of TEK based on observations: Comparison between Pawaia and tinoni Simbo

Megapodes and their eggs are widely used by Pawaia people (Hide et al, 1984; Mack and West, 2005) and tinoni Simbo (Hocart, 1922; Sibley, 1946; Sinclair, 1999) and these peoples have an extensive TEK of them.

Older Pawaia men had a broader knowledge of megapodes than did older women (higher certainty; see Table 10.4). Given that TEK is experiential (Moller et al, 2004), this difference is probably due to the different ways in which men and women interact with megapodes. As Pawaia men spend more time hunting than do Pawaia women (Toft, 1983; Ellis, 2002; Mack and West, 2005), they may encounter megapodes more often and learn more about them.

In contrast, tinoni Simbo men and women were equally certain in their answers (see Tables 10.2 and 10.4). On Simbo Island, incubation sites are localized in fields close to villages and both men and women regularly harvest megapode eggs; as a result, they may encounter megapodes equally often and thus have a similar breadth of TEK.

Older Pawaia men also had a broader knowledge of megapodes than did younger men (see Table 10.4); the quality and quantity of TEK has been found to vary in a similar way in other studies (Johnson, 1992; Usher, 2000). Younger Pawaia men are less experienced than their older kinsmen, which may explain why they were less certain in their TEK. In the experience of the authors, the more formal schooling that young men have had in Haia village, the less TEK they seem to know, so time spent in school may also limit the amount of TEK young people learn (Johannes, 1989; Baines and Hviding, 1992).

TEK of a species is likely to be less detailed and less reliable for behaviour and ecology that is rarely encountered. For example, among Pawaia people there was relatively low precision and accuracy in assigning mating systems to Brush-turkeys and New Guinea Megapodes (see Tables 10.1 and 10.3). Pawaia people have few observations of megapode breeding behaviour because they do not set up hides to hunt or trap megapodes at mounds; as a consequence, their TEK regarding breeding behaviour is less reliable than it is for other aspects of the biology of megapodes. Likewise, the TEK of tinoni Simbo was less reliable in areas that required repeat observations of the same bird or egg – questions such as clutch size, incubation time of eggs and longevity of megapodes (see Table 10.2) – because they harvest eggs the first time they encounter them and cannot distinguish between individual birds.

For behaviour and ecology most commonly encountered, TEK is likely to be most reliable (Fraser et al, 2006). Both tinoni Simbo and Pawaia people were 100 per cent certain, precise and accurate in their TEK of the months in which eggs are laid (see Tables 10.1 to 10.3) because they both regularly collect eggs. Pawaia people regularly visit megapode mounds to dig into them to harvest eggs (Hide et al, 1984) and they recognize subtle differences in the composition and location of mounds among the three species (see Table 10.3) that are consistent with SEK (e.g. Sinclair, 2001b, 2002).

Although TEK may be precise, it is not a homogeneous knowledge system (Sillitoe, 1998; Wenzel, 1999; Usher, 2000; Davis and Wagner, 2003; Fraser et al, 2006). For example, some Pawaia women were very certain (maximum 88 per cent of questions answered) and highly accurate (maximum 90 per cent consistency with SEK) (see Table 10.4); but two women answered all questions with 'I do not know'. Such heterogeneity occurs in all knowledge systems (Davis and Wagner, 2003) and is recognized by indigenous peoples, who use informal filters to distinguish reliable from unreliable TEK themselves (Newman and Moller, 2004).

It is possible that some of the TEK of individual Pawaia people scored as unreliable may have been reliable but was based on finer spatial scales than SEK or the TEK of Pawaia people as a whole. For example, one respondent said that Talegallas build mounds away from large trees, whereas 80 per cent of those interviewed stated the opposite (see Table 10.3). In a study of selection of incubation sites at three locations on Pawaia lands, Sinclair (2002) found that at one study site Talegalla mounds had significantly more large trees near the mound than for the other species, whereas at another study site the opposite was true.

By choosing questions for the survey that had answers in SEK, this study was biased towards knowledge where the methods used to generate SEK are strong, whereas the methods used to generate TEK may have other strengths. For example, as there are no long-term scientific data for the species studied, TEK and SEK could not be compared with respect to changes that have occurred through time. As TEK is based on a long time series (Moller et al, 2004; Fraser et al, 2006), it is ideally suited to answer such questions. Furthermore, some of the SEK may be unreliable in comparison with TEK. Although most of the SEK used in this chapter was derived from the scientific method, some are anecdotes and observations without sample sizes, estimates of error or having been subjected to the peer review process. Given these potential biases, the accuracy of the TEK measured against it may be underestimated.

Comparing scientific and traditional ecological knowledge

The three predictions from the hypothesis that TEK from direct observations is reliable knowledge were supported: TEK from direct observations was widely known among Pawaia people and tinoni Simbo (high certainty), it was consistent within and among sex and age groups (high precision), and was similar to SEK (high accuracy) (see Table 10.4). This observational knowledge is common to the two systems and is generally derived from methods where they are most similar: observation and inductive reasoning. For example, Pawaia people visit the same mounds repeatedly to harvest eggs, and the average number of eggs that they say megapodes lay per year (i.e. 12 to 14 eggs) is very similar to estimates made by the authors over a 15-month study. Although induction is much maligned among philosophers of science, it remains an important method of gaining SEK (Guthery, 2007) and TEK, and knowledge gained from induction is an area of overlap in the two knowledge systems.

The three predictions from the second hypothesis that TEK from interpreting observations is unreliable knowledge, which were just the inverse of those for the first hypothesis, were also supported: TEK of Pawaia people from their interpretation of observations had low certainty, precision and accuracy (see Table 10.4). When it comes to interpreting observations, TEK and SEK diverge in their methods and also in the knowledge that these methods generate. What scientists would consider a hypothesis or prediction to be tested, Pawaia people presented in some cases as knowledge. For example, according to both knowledge systems, New Guinea Megapode mounds have lower organic content than those of Brush-turkeys, but are larger (see Table 10.3; Sinclair, 2001b).

Studies of temperature regulation in megapode mounds show that lower organic content results in less heat production, but a larger size means less heat loss, resulting in the same stable incubation temperatures for different-sized mounds with differing organic contents (Seymour and Bradford, 1992; Sinclair, 2001b). The TEK of Pawaia people regarding these differences included alternative interpretations for larger mounds in New Guinea Megapodes, such as larger mounds reduce losses of eggs to predators – a plausible hypothesis but one that needs to be tested before it is accepted as reliable knowledge.

Unreliable TEK is not necessarily useless. Beyond any utility for scientists in generating hypotheses, unreliable TEK may be useful for indigenous people even if it is false. For example, another explanation from TEK for larger mounds for New Guinea Megapodes compared to Brush-turkeys is that more than one pair use New Guinea Megapode mounds. Intra-specific sharing of mounds occurs in *Megapodius*, including on Pawaia lands (Sinclair, 2002), and in one study reporting such sharing, larger mounds contained more eggs (Sankaran and Sivakumar, 1999). If Pawaia harvesters make their decision on whether to harvest eggs or how many to collect based on the size of the mound, this is a sensible decision regardless of whether the informing TEK is reliable.

This study shows that TEK may provide researchers with reliable knowledge that can be gained without using large amounts of precious research time and funds. It also reveals the limits to the methods of TEK in generating reliable knowledge: TEK from interpreting observations of megapodes was unreliable. These limits highlighted where SEK can most usefully complement TEK and where conservation biologists can best assist indigenous peoples: the scientific method can reliably identify causal relationships that the methods of TEK may not reveal (Newman and Moller, 2004). For example, tinoni Simbo observed that after a 61-day closed season during which there was no harvesting, most eggs contained embryos, suggesting that the closed season was too short to allow eggs to hatch. However, neither their TEK nor the methods they use for gaining it were able to suggest the best length of a closed season. The suggestion that a 61-day closed season is too short was used as a research hypothesis to test using the scientific method (Sinclair, 1999). Using existing SEK, TEK and collecting data on variables such as incubation period, it was possible to build a mathematical model and advise tinoni Simbo on how many chicks would be produced by closed seasons of varying lengths (Sinclair 2001a). Tinoni Simbo then balanced this new knowledge against other considerations (e.g. longer closed seasons mean increased economic hardship in the short term) and made a decision to instigate a 91-day closed season (Sinclair, 2001a).

Integrating scientific knowledge and traditional knowledge

Because of the limited resources that developing nations have for conservation and the system of land tenure in places such as Melanesia, much resource management in the foreseeable future will be by indigenous peoples and informed by their TEK. In this context, social as well as biological values need to be taken into account in conservation projects (West and Brockington, 2006) further suggesting that SEK and TEK should be integrated. If conservation biologists are to do this they need evidence that TEK is reliable, as presented in this chapter.

If a knowledge system is to remain resilient it must inform its users satisfactorily (Bradshaw and Bekoff, 2001). TEK has informed the resource use of Pawaia people and tinoni Simbo for millennia and has been reliable enough to ensure some sustainability: daily wild-meat consumption among Pawaia people, for instance, has remained stable for over 20 years (Mack and West, 2005). The challenge for indigenous peoples in a rapidly changing world is to determine what parts of their TEK are reliable enough to ensure sustainable use in the future. When they find that TEK that is not reliable, they must then supplement this with more reliable knowledge or generate new knowledge, just as tinoni Simbo did with the authors for megapodes, and other indigenous harvesters have done for other species (e.g. Māori for seabird harvests in New Zealand; Newman and Moller, 2004).

Both SEK and TEK have their strengths and weaknesses (Johnson, 1992). One role of conservation biologists and community workers is to identify these and find ways in which the two systems can complement each other in solving resource management problems. Surveying TEK and discussing SEK in that context is one way to find common ground and facilitate integration of the two knowledge systems (Becker and Ghimire, 2003; Newman and Moller, 2004; Fraser et al, 2006).

Although many authors point to a role for TEK in supporting or enhancing SEK (e.g. Nabhan, 2000; Donovan and Puri, 2004; Sheil and Lawrence, 2004), the opposite can also be the case: SEK should support and enhance TEK, not replace or supplant it (Baines and Hviding, 1992; Moller et al, 2004; Fraser et al, 2006).

Just as scientists work more successfully in teams that agree on essential tenets of their programme (Hull, 1988), conservation projects will be more successful if indigenous peoples and outside researchers agree on some fundamental knowledge and accept that each have operationally valid methods of generating it. Moreover, indigenous peoples are more likely to incorporate SEK within their TEK if it supports their observations (Moller et al, 2004), just as scientists are more likely to incorporate a finding into their knowledge if it supports their research (Hull, 1988).

The approach advocated for integrating SEK and TEK will benefit from a meta-communication framework where there is an interest-free exchange of information between conservation biologists and indigenous peoples. Openness about respective agendas is also required, or groups should at least attempt to understand their respective agendas and work within that context. Assumptions about agendas and poor communication lead to misunderstandings and conflict that can impact negatively upon conservation projects (for examples from Melanesia, see McCallum and Sekhran, 1997; Filer, 2004; West, 2006).

The scientific study of traditional ecological knowledge

It may appear implicit in the approach used in this chapter that the authors view TEK as a series of disembodied facts. TEK is undoubtedly part of a social and spiritual complex (Berkes, 1999) and is important for its socio-cultural and intrinsic value (Berkes et al, 1994); yet, part of TEK is comprised of facts that do not necessarily lose meaning outside their cultural or historical context (compare Ellis and West, 2004). A full understanding of TEK requires application of the anthropological method (Johannes, 1989; Sillitoe, 1998), and the incorporation of anthropologists as 'knowledge brokers' (Sillitoe, 1998, p247) in conservation projects will produce a richer, more differentiated understanding of TEK. Having said this, there is room for the study of TEK by disciplines other than anthropology and what anthropologists know or can achieve in studying TEK should not be exaggerated (Brokensha, 1998). For example, a researcher who is not biologically literate is not equipped to assess what knowledge is new, important or biologically plausible (Johannes, 1993), or may be given a simplified version of TEK when not considered sufficiently knowledgeable to understand more complex explanations (Diamond, 1989).

In this study science has been used to define 'useful' TEK (Stirrat, 1998) and the analysis was restricted to conservation and biology because these are the areas of interest and expertise of the authors. Viewing TEK in this way is, however, little different from how local partners viewed SEK: when asking about SEK in their decision-making (Sinclair, 2001a), tinoni Simbo were not interested in the social and historical context of this knowledge, but in its reliability and usefulness to them. Furthermore, tests of the reliability of TEK presented here are similar to the self-correcting process used by indigenous people as their knowledge evolves – only the tools differ: each generation tests the reliability of existing TEK against their own observations, experiences and informal experiments (Johnson, 1992).

Recommendations for studies of TEK by biologists

To gain reliable knowledge from TEK, studies should focus on species and processes that local people have commonly encountered over a long time series and on TEK based on direct observations rather than interpretations of observations. Other considerations should be the way in which people interact with the species or process in question, and recording some TEK for which SEK exists and can be compared.

More insight from TEK may be gained from experts (as sampled on Simbo Island) than from using a random sample of local people (as sampled in Haia village; Ferguson and Messier, 1997; Huntington, 2000; Usher, 2000), although this would depend on the purpose of the study. Most publications reporting TEK do not indicate the number of informers from whom the knowledge has been recorded, nor do they state how informers were selected (Davis and Wagner, 2003): what constitutes an 'expert' and how many have been surveyed should be explicitly stated in studies. Heterogeneity in TEK has important implications for sampling, with pilot studies needed to estimate variability to determine adequate samples or whether key informants should be used (Huntington, 2000; Yamada et al, 2003; Fraser et al, 2006).

Several research methodologies have been proposed that either incorporate measures of reliability or that take into account different types of knowledge, and these are a useful basis on which to design projects (e.g. Ferguson and Messier, 1997; Calheiros et al, 2000; Usher, 2000; Davis and Wagner, 2003). Integration of TEK and SEK will best be achieved if biologists recognize the limits of their methods and become involved in interdisciplinary research with social scientists (Ellis and West, 2004), even before projects are initiated (West and Brockington, 2006).

Conclusions

Megapodes were chosen to investigate TEK because the authors study this family of birds and because there are published accounts of their natural history. A subset of the TEK of Pawaia people and tinoni Simbo based on their observations of megapodes was found to be reliable knowledge. It is likely that the observational TEK of these peoples concerning other species and processes will be equally reliable, particularly for those with which they interact closely. For Pawaia, the TEK based on interpreting their observations was less reliable. This TEK does, however, reveal where conservation biologists can assist indigenous peoples, and where SEK could complement TEK by providing insights into natural processes that could be examined using the scientific method (Moller et al, 2004; Newman and Moller, 2004; Fraser et al, 2006).

Where field research has not been undertaken, expert knowledge is especially important (Yamada et al, 2003); TEK is expert knowledge often about a biota that may not have been formally studied and in such cases can be an effective way to learn rapidly and inexpensively about a species or ecological system (Dwyer, 1982; Telfer and Garde, 2006).

TEK alone may not be enough to ensure sustainability in a rapidly changing world (Dwyer, 1982; Berkes et al, 1994; Moller et al, 2004), as is graphically illustrated by the mass extinctions, including many species of megapode, attributed to indigenous peoples in Oceania (Steadman, 2006). In such a context, working with indigenous peoples to integrate SEK within their TEK is a sensible approach for conservation biologists, particularly when working within restrictive project budgets and timeframes. Doing this not only increases the chances of achieving conservation, it may also result in conservation of the cultural diversity that generated the TEK (Gadgil and Berkes, 1991), empowers indigenous peoples (Berkes, 2004) and is consistent with the human rights and ethics that should underpin such work (Alcorn and Royo, 2007; Campese and Guignier, 2007).

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