Ecology of Food and Nutrition, 52:451–478, 2013
Published with license by Taylor & Francis Group, LLC
ISSN: 0367-0244 print/1543-5237 online
DOI: 10.1080/03670244.2013.768122

Wild Foods from Farm and Forest in the East Usambara Mountains, Tanzania

BRONWEN POWELL
School of Dietetics and Human Nutrition and the Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Montreal, Quebec, Canada, and Center for International Forestry Research (CIFOR), Bogor, Indonesia

PATRICK MAUNDU
Bioversity International, Nairobi, Kenya

HARRIET V. KUHNLEIN and TIMOTHY JOHNS
School of Dietetics and Human Nutrition and the Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Montreal, Quebec, Canada

This study explored the role of wild foods in the diets of children and mothers in the East Usambara Mountains (N = 274 dyads). We identified 92 wild food species. Although dietary diversity (most measures) was not different between seasons, wild foods accounted for a greater percentage of items consumed in the wet (food insecure) season. Many wild foods were obtained on farm; wild foods obtained from the forest accounted for less than 3% of food items consumed. Wild foods were used by virtually all informants but contributed only 2% of total energy in the diet. However, they contributed large percentages of vitamin A (RAE) (31%), vitamin C (20%), and iron (19.19%). Agricultural factors (e.g., hours spent in farm) were associated with greater wild food use. These findings suggest participation in agriculture may be important for the maintenance of wild food use, and that wild foods can play an important role in the nutritional resilience of local people.

KEYWORDS agriculture, biodiversity, conservation, dietary diversity, nutrition, wild food

Address correspondence to Bronwen Powell, School of Dietetics and Human Nutrition and the Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Montreal, Quebec H9X 3V9, Canada. E-mail: bronwen.powell@hotmail.ca

INTRODUCTION

"Wild" foods (defined here as any uncultivated species, plant, or animal) are an important part of many local and traditional food systems (Kuhnlein and Receveur 1996), food systems that, for many rural people in developing countries, have formed the foundation of food and nutrition security for generations. Such food systems include culturally-important and locally-available foods from hunting, gathering, and small-scale agriculture; the technologies needed to obtain, process and prepare them; and, associated social and cultural characteristics, beliefs, and practices (including traditional knowledge; Kuhnlein and Receveur 1996). Local food systems are defined by environmental, social, economic, and cultural contexts in which they occur (Kuhnlein 2009). Major features of local environments shape traditional food systems and are an essential part of their integrity. In forested landscape mosaics, such as in many parts of rural Africa, wild foods from forests and areas with tree cover have historically played a central role in the food system.

In many regions an important, if controversial, type of wild food from forested areas is bush meat, which can provide an excellent source of protein and micronutrients (Fa, Currie, and Meeuwig 2003; Nasi et al. 2008; van Vliet et al. 2010). In a paper using data from Madagascar, Golden and colleagues (2011) estimate that the loss of wild meat from the diets of children would result in a 29% increase in the number of children suffering from anemia. Wild plant foods can also make significant contributions to micronutrient intakes (Fleuret 1979b; Grivetti and Ogle 2000; Ogle et al. 2001), and many authors have noted the importance of wild foods for providing a safety net for local people in times of food insecurity (Colfer et al. 2006; Falconer 1990; Humphry et al. 1993). For example, in Niger 83% of informants reported increased reliance on wild foods during drought (Humphry et al. 1993). In these settings, the ability of local ecosystems to provide food security without the destruction of forest integrity is key to the sustainability of conservation efforts.

In many food systems wild foods are important for dietary diversity and adequate nutrient intake throughout the year (Butler 2008; Colfer 2008; Colfer et al. 2006; Johns and Maundu 2006). This is true not only for hunter-gatherer societies but for many agricultural societies as well (Bharucha and Pretty 2010; Johnson and Behrens 1982). Because most wild foods from both the farm and the forest are low in salt and fat and high in fiber and micronutrients, they could play an important role in mitigating the nutrition transition which is leading to increased rates of obesity and chronic, diet-related diseases such as type II diabetes and cardiovascular disease in developing countries around the world (Batal and Hunter 2007; Maletnlema 2002; Popkin, Lu, and Zhai 2002).

Wild plant food use has been described in diverse communities (e.g., Batal and Hunter 2007; Delang 2006; Etkin 1994; Fleuret 1979b; Grivetti and Ogle 2000; Herzog, Farah, and Amadò 1994; Ladio and Lozada 2004; Maroyi 2011; Moreno-Black and Somnasang 2000; Pieroni et al. 2005; Price 1997; Termote, Van Damme, and Dhed'a Djailo 2010, 2011; Vainio-Mattila 2000) and their nutrient composition is increasingly reported (e.g., Lyimo, Temu, and Mugula 2003; Msuya, Mamiro, and Weinberger 2008; Nordeide et al. 1996). Yet, few studies have expressly examined the contribution wild foods make to actual nutrient intake and dietary diversity (Ogle et al. 2001). We seek to draw connections between biodiversity, from across the landscape mosaic, and nutrition, by exploring the contribution of wild foods from the forest and the farm to dietary diversity and nutrient intake and, by demonstrating increased use of wild foods during the period of seasonal food shortage. The role of forest and wild foods in local food systems provides an important focus through which interventions may be able to simultaneously conserve local biodiversity and improve local people's health and well-being.

STUDY AREA: THE EAST USAMBARA MOUNTAINS

Located 40 km from the Indian Ocean coast in northeastern Tanzania, the East Usambara Mountains rise to over 1,200 m and receive over 1,500 mm of rain annually (data from 2007– 2009) (figure 1). Traditionally, home to the Wasambaa (Shambaa) tribe, the East Usambaras are known for their cultural diversity; home also to the Bondei and Zigua tribes (Feierman 1974; Willis 1992). Human population density in the East Usambaras is 61 people per square kilometer and growing at an annual rate of approximately 2.4% (National Bureau of Statistics Tanzania 2002).

Micronutrient undernutrition remains a major problem in Tanzania (UN-SCN 2004), and in the East Usambaras specifically. In 1994 high rates of stunting (height-for-age Z score ≤ -2; 60%), anemia (Hb $\leq$ 110 g/L) (49%) and parasitic infection were reported in children between the ages of 7–12 years in Muheza District in the East Usambara Mountains (Beasley et al. 2000).

Today, local livelihoods are based on small-scale farming. Subsistence crops that are cultivated include: bananas, maize, cassava, beans, yams, and rice. Sugar cane, cardamom, cinnamon, cloves, black pepper, teak, and oranges are common cash crops. Other common sources of income include wage labor in the tea estates or timber industry, small business, and livestock keeping.

Part of the Eastern Arc Mountains, the East Usambaras contain moist tropical forest within a mosaic of forests, open fields, agroforests, fallows and settled land (Dewi and Ekadinata 2010; Hall, Gillespie, and Mwangoka 2010). The area has experienced a high rate of deforestation in the past 30 years, threatening the ecological and biological value of the remaining tracks of forests which are internationally recognized for their remarkable species diversity and high level of endemism (Burgess et al. 2007; Myers

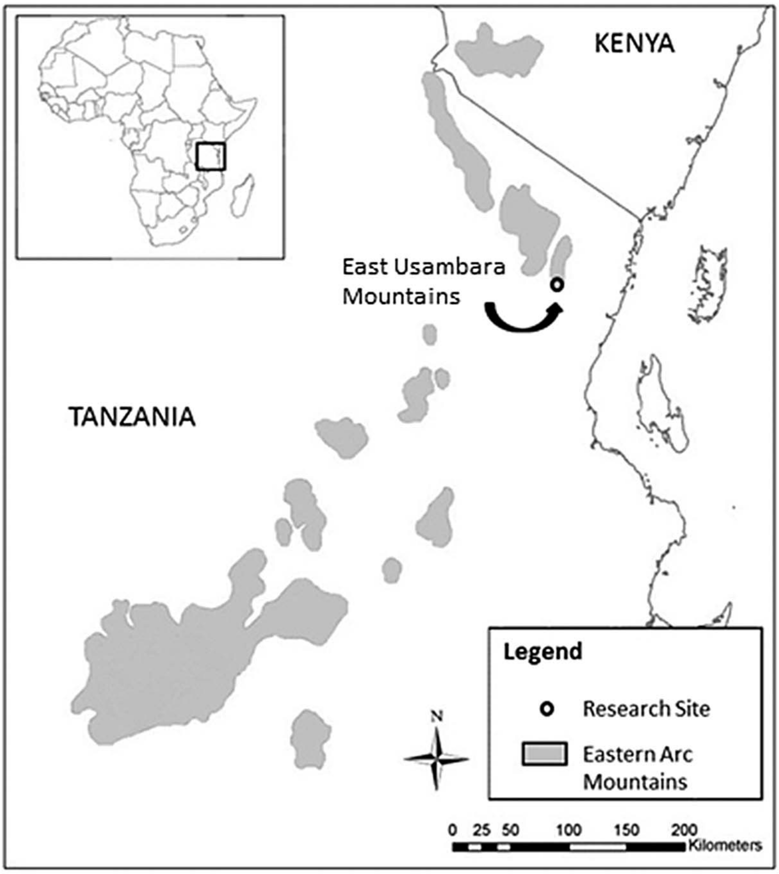

FIGURE 1 Map showing location of the East Usambara Mountains.

et al. 2000). The Eastern Usambara Mountains are home to some of the oldest protected areas in East Africa; these have historically been managed in an exclusionist manner, with strict restrictions on use by local people. Despite efforts to decentralize forest management in Tanzania, including in the East Usambaras, use of protected government forests for food (and other resources) remains limited (Vihemäki 2005).

The area is well known for the diversity of wild foods used (Fleuret 1979a; Fleuret 1979b; Ruffo, Birnie, and Tengnas 2002; Vainio-Mattila 2000). Previous research from the area suggests that historically the majority of vegetables consumed were wild species (many obtained from agricultural land) and that wild meat had a culturally (and presumably nutritionally) important role in the local diet (Feierman 1974; Fleuret 1979b). Recent research indicates that people in the area use a greater diversity of wild vegetables and a higher ratio of wild to cultivated vegetables than do people in other parts of Tanzania (Keding et al. 2007; Weinberger and Swai 2006). Woodcock (1995) suggested that communities living adjacent to public forests (to which they have legal access) collect a wider range of wild foods and show a greater preference for forest derived foods than communities adjacent to reserves (where there is no legal access to forest resources).

METHODS

Six villages (Misalai, Shambangeda, Kwatango, Bombani, Tongwe, and Kiwanda) were selected based on stratification for elevation, road access and distance to the market center, Muheza town. Additional maps showing the location of the study villages, study households, roads and land use / land cover can be found in Powell and Johns (2011) and Powell (2012). Within each village, approximately 45 households were selected using systematic sampling from a list of households with children under five years old provided by village governments (in this case of systematic sampling, every second or third house was selected, or about 50% of eligible houses per village, total $N = 274$). Dietary intake information was collected for one child (the youngest in the house between two and five years) and their mother (or primary caregiver, henceforth referred to as mother) during the long rainy season, from March to May 2009, and, at the end of the dry seasons, September to October 2009 (in only three of the six villages, $N = 129$, in the dry season). Research underwent ethics review at McGill University and the national ethics board in Tanzania (COSTECH) and research agreements were signed with village governments. Free and informed consent, obtained verbally from adults and guardians of children, was recorded by an enumerator and confirmed by the lead researcher, prior to interviews.

Dietary information was collected using a qualitative 7-day food-use questionnaire and two 24-hour recalls on non-consecutive days of the week (multi-pass technique, using local serving size aids) in the wet season and a 7-day food-use questionnaire and one 24-hour recall in the dry season. A 7-day Food Variety Score (FVS—number of unique food items consumed) and a 7-day dietary diversity score (DDS_6—number of food groups, out of 6, consumed) were calculated from the food-use questionnaire. A 1-day FVS and DDS_6 were calculated from the first 24-hour recalls (see Powell 2012 for more details). Data from the 24-hour recalls were entered into the computer program CANDAT (Godin 2007; London, Ontario, Canada) and energy and nutrient intake were determined using nutrient composition data for local foods obtained from: the *Tanzania Food Composition Tables*, the *Food and Agricultural Organization Food Composition Tables*, the United States Department of Agriculture Nutrient Database and scientific literature (Lukmanji et al. 2008; Wu Leung 1968).

The source of each food item consumed was recorded, and the relative contribution of foods from each source to diet (over 7 days) and nutrient intake was calculated. Sources of food recorded included: (1) purchased foods (store, market, vendor, and local restaurant); (2) farm (garden was combined with farm because its use and definition was inconsistent across informants, this category includes fallow which people consider part of their farm); (3) gift (including foods consumed at a friend's house or funeral); and (4) foods from forest or uncultivated land (river, bush, etc.). The contribution of wild foods from any source was also calculated. Wealth was assessed by participatory, community-based ranking, described elsewhere (Powell 2012). Forest use and agricultural data were collected by questionnaire completed with the head of each household. Differences between the wet and the dry seasons were tested using paired *t*-tests and, associations between percent of the diet from wild species and economic and environmental factors were tested using correlations in SPSS Student Pack 17.

RESULTS

Wild Foods from the Farm and Forest in the Local Food System

Wild foods were used by virtually all informants (98.3% in the wet season and 93% in the dry season). A total of 92 species of wild (or spontaneous growing/uncultivated) foods were reported in the dietary surveys conducted between March and May, and September and October 2009 (table 1). Table 1 highlights the percent of individuals reporting use in the last seven days in both seasons; the percent of times that a species was obtained from the farm or forest/uncultivated land; and, the primary source (most commonly reported) for each species (additional species were identified as available in the communities but were not listed here as they were either not in season during the survey periods or were consumed too infrequently). Of food items, 26 were primarily (> 50% of times used) obtained from the forest while 45 were obtained from the forest a minimum of 10% of the time they were used (second to last column in table 1). Figures 2 and 3 show the food groups represented by wild species and wild foods obtained from the forest at least 10% of the time.

The largest category of wild foods species (from any source) was vegetables. In the wet season 94.1% of mothers and 91.5% of children had consumed one or more wild vegetable species in the previous week (mean number of species consumed was 4.1 ± 2.8 for mothers and 4.0 ± 2.8 for children).

Many wild foods from the forest were birds and mammals (figure 3 and table 2), which, although consumed infrequently, can make important contributions to micronutrient intake, even in small quantities (Arnold et al. 2011; Murphy and Allen 2003). Only 6.1% of individuals had consumed any type of wild animal or bird in the last week, compared with 67.8% of individuals who had consumed domestic meat or fowl in the last

TABLE 1 List of Wild Food Species Reported by One or More Individuals in Either the Wet or the Dry Season, Percent of Individuals Reporting Their Use by Seasons and Source

Scientific name*	Identification[1]	Swahili name	English name	% Reporting use—wet season[2]	% Reporting use—dry season[3]	% Obtained from farm (wet)	% Obtained from forest[4]	Primary source[5]
Vegetables								
Amaranthus spp.[6]	BP2009-75 & 77	Mchicha/ bwache	Amaranth	76.3	61.2	67.5	1.4	Farm
Launaea cornuta (Hochst. ex Oliv. & Hiern) C.Jeffrey	BP2008-3	Mchunga	Bitter lettuce	71.0	45.0	97.9	0.5	Farm
Corchorus olitorius L. and other *Corchorus* spp.	BP2009-7, BP2009-183	Kibwando/ hombo	Jute	59.2	10.9	98.8	0.0	Farm
Bidens pilosa L., possibly also *Bidens schimperi* Sch.Bip. ex Walp.	BP2009-3–6, BP2009-48–50	Mbwembwe/ kisho wa nguo	Black jack	54.4	34.1	98.6	1.4	Farm
Manihot glaziovii Müll.Arg.	x	Kisamvu cha mpira	Tree cassava	34.2	29.5	73.1	22.0	Farm
Basella alba L.	BP2009-88–91	Ndelema	Vine spinach	25.9	14.0	75.2	10.6	Farm
Manihot esculenta Crantz.[6]	Picture	Kisamvu cha Mihogo	Cassava leaves	17.5	2.3	97.9	2.1	Farm
Solanum americanum L., *Physalis angulata* L.[6]	BP2009-85–87, BP2009-122–125	Mnavu	American black nightshade, cutleaf groundcherry	15.4	11.6	77.4	2.4	Farm
Asystasia gangetica (L.) T. Anders., *A. mysorensis* (Roth) T. Anders. (*A. schimperi* T. Anders.)	BP2009-13, BP2009-135–137, BP2009-161–162, BP2009-192–194	Tikini	x	11.8	3.9	98.4	0.0	Farm

(*Continued*)

TABLE 1 (Continued)

Scientific name*	Identification[1]	Swahili name	English name	% Reporting use—wet season[2]	% Reporting use—dry season[3]	% Obtained from farm (wet)	% Obtained from forest[4]	Primary source[5]
Dioscoreophyllum volkensii Engl.	BP2009-101, BP2009-112–114	Msangani	x	11.4	17.4	64.5	32.3	Farm
Ipomoea pes-caprae (L.) R.Br., *Ipomoea aquatica* Forssk.	BP2009-29–31	Talata	Water spinach	9.4	7.0	92.2	3.9	Farm
Erythrococca kirkii Prain., *Erythrococca fischeri* Pax.	BP2009-8, 20–22, 102–103, 187–188	Mnyembeue	x	7.4	3.1	100.0	0.0	Farm
Alternanthera sessilis (L.) R.Br. ex DC.	BP2008-11–13, BP2009-94–96	Mkoswee	Sessile joyweed	4.4	7.0	100.0	0.0	Farm
Justicia anagalloides T.Anderson	BP2009-32, 132–33, 158–160	Zuma	x	4.4	1.6	91.7	8.3	Farm
Ormocarpum kirkii S.Moore (or *O. trichocarpum* (Taub.)Engl.)	x	Hombo ya Munguu	x	4.4	0.8	58.3	33.3	Farm
Rourea orientalis Baill.	Picture	Kisogo	x	4.0	5.8	81.8	18.2	Farm
Platostoma africanum P.Beauv.	BP2009-4 & 5, BP2009-24–28	Kisugu/kisungu	x	3.7	5.8	80.0	20.0	Farm
Sonchus oleraceus L. and *Sonchus asper* (L.) Hill.	BP2009-195–197	Kwake/pwake	Sow thistle	2.9	0.0	75.0	25.0	Farm
Talinum portulacifolium (Forssk.) Asch. ex Schweinf. or *T. triangulare* Willd.	Picture	Tonge/tee	x	2.6	0.8	85.7	14.3	Farm

Lobelia fervens Thunb. and *Lobelia duriprati* T.C.E.Fr.	BP2009-81–83, 118-121	Sambae/ shambaee	Lobelia	2.0	5.4	90.9	0.0	Farm
Celosia trigyna L.	BP2009-175–177	Funga-msnaga	x	1.1	2.3	100.0	0.0	Farm
Nasturtium officinale R.Br. *(Rorippa nasturtium-aquaticum* (L.) Hayek)[7]	x	Sawade/salade	Watercress	0.7	0.8	100.0	0.0	Farm
Unknown	x	Kihombo mbunda	x	0.7	0.0	100.0	0.0	Farm
Unknown	x	Kikunga	x	0.7	0.0	50.0	50.0	Farm
Physalis angulata L.	BP2009-173–175	Kimbwabwa/ mnavu in some places	Cutleaf groundcherry	0.7	0.0	100.0	0.0	Farm
Emilia coccinea G.Don	BP2009-33–35	Limi ya ng'ombe/ msunga	x	0.7	0.0	100.0	0.0	Farm
Aerva lanata (L.) Schultes, *Alternanthera sessilis* R.Br.	BP2009-14–16, BP2009-23, BP2009-186	Tebwa	x	0.7	0.0	100.0	0.0	Farm
Momordica foetida Schumach.	BP2009-2, 76, 91, 214 & 215	Ushwe	x	0.6	0.0	100.0	0.0	Farm
Portulaca oleracea L.	BP2009-138–140	Danga-danga/ tako la hasani	Purslane	0.4	0.0	100.0	0.0	Farm
Unknown	x	Kisiwani	x	0.4	0.0	100.0	0.0	Farm
Trichodesma zeylanicum R.Br.	x	Sasamlanda	x	0.4	0.0	100.0	0.0	Farm
Fruit								
Psidium guajava L., *P. cattleyanum* Weinw.	Picture	Mapera	Guava/strawberry guava	42.5	30.2	88.3	3.0	Farm

(*Continued*)

TABLE 1 (Continued)

Scientific name*	Identification[1]	Swahili name	English name	% Reporting use—wet season[2]	% Reporting use—dry season[3]	% Obtained from farm (wet)	% Obtained from forest[4]	Primary source[5]
Artocarpus heterophyllus Lam.	Picture	Mafenesi	Jack fruit	28.5	20.2	87.1	1.3	Farm
Mangifera indica L.	x	Maembe	Mango	12.9	2.3	15.7	4.3	purchased
Rubus pinnatus Willd. and *Rubus rosifolius*	BP2009-37–39, BP2009-57–59	Vishaa	Wild raspberry	11.0	0.0	78.3	21.7	Farm
Elaeis guineensis Jacq.	Picture	Mbese	Palm oil fruit	9.4	9.3	82.4	3.9	Farm
Physalis peruviana L.	BP2009-45–47	Vichupwa	Ground cherry	4.4	1.6	100.0	0.0	Farm
Eriobotrya japonica (Thunb.)Lindl.	Picture	Msambia	Loquat	4.6	0.8	80.0	4.0	Farm
Myrianthus arboreus Beauv. (maybe)	x	Makonde	x	4.6	0.0	84.0	16.0	Farm
Terminalia spp.	x	Kungu	x	2.4	0.0	76.9	0.0	Farm
Syzygium malaccense (L.) Merr. & L.M.Perry	Picture	Mfyoksi	Water apple	2.4	0.0	46.2	15.4	Farm
Vangueria infausta var *rotundata* Burch.	BP2009-67	Mviru	Medlar	1.5	3.5	87.5	12.5	Farm
Passiflora foetida L.	BP2009-8–10, BP2009-104–106	Dodoki/matunda nyau	Wild passion fruit	1.3	2.3	100.0	0.0	Farm
Sorindeia madagascariensis DC.	Picture	Mkimgwina	x	1.3	0.0	14.3	28.6	Forest
Syzygium cumini (L.) Skeels	BP2009-208–210	Zambaru	Java plum	1.3	0.4	42.9	28.6	Farm
Sclerocarya birrea (A.Rich.) Hochst. (not very sure)	x	Mng'ong'o	Marula tree	1.1	0.4	50.0	0.0	Farm

Momordica calantha Gilg.	BP2009-216 & 217	Matoyo	x	0.9	0.4	80.0	20.0	Farm
Unknown	x	Vitole		0.4	0.0	0.0	100	Forest
Saba comorensis (Bojer) Pichon	Picture	Maungo/ ungoungo	White rubber vine	0.2	0.0	0.0	100	Forest
Ancylobothrys petersiana Pierre	x	Vitoria		0.2	0.0	0.0	100	Forest
Lantana camara L.	BP2009-147–149, BP2009-190 & 191	Mvuti	x	0.2	0.8	100.0	0.0	Farm
Vitex doniana Sweet[7]	Picture	Ngobe/magobe	x	0.0	17.8	*x*	*x*	x
Adansonia digitata L.	x	Ubuyu	Baobab fruit	0.0	12.4	*x*	*x*	x
Mushrooms (Counted as a type of vegetable in dietary calculations)								
Unknown	x	Nkuuri	x	2.9	0.8	87.5	0.0	Farm
Many	x	Mangaa	x	2.2	0.0	83.3	16.7	Farm
Unknown	x	Nyika	x	0.4	0.0	100.0	0.0	Farm
Auricularia spp.	x	Magh'wede	x	0.4	0.0	0.0	100	Forest
Polyporus spp.	x	Ngaha/nyaha	Thin bracket fungi	0.4	0.0	100.0	0.0	Farm
Unknown	x	Kusaghizi	x	0.4	0.0	100.0	0.0	Farm
Pleurotus spp (*P. djamor*)	x	Mameno/ mamama	Oyster mushroom	0.4	0.0	0.0	100	Forest
Unknown	x	Untondoo	x	0.4	0.0	100.0	0.0	Farm
Termitomyces aurantiacus	x	Magong'ongo	Termitomyces	*x*	*x*	*x*	*x*	x
Termitomyces letestui	x	Vitundwi	Termitomyces	*x*	*x*	*x*	*x*	x
Honey								
x	x	Asali	Honey	7.7	2.7	0.0	21.4	Purchased

(*Continued*)

TABLE 1 (Continued)

Scientific name*	Identification[1]	Swahili name	English name	% Reporting use—wet season[2]	% Reporting use—dry season[3]	% Obtained from farm (wet)	% Obtained from forest[4]	Primary source[5]
Fish and other aquatic species								
Oreochromis spp., *Tilapia* spp.	x	Pelege	Tilapia	71.0	67.4	0.0	6.7	Purchased
Many	x	Magonyoo	Craw fish	13.1	3.9	0.0	88.7	Forest[7]
Clarias spp.	x	Kambale	Cat fish	12.1	3.9	0.0	69.7	Forest[7]
Labeo victorianus	x	Ningu	Ningu	10.3	1.6	0.0	96.4	Forest[7]
Many	x	Kaa	Crabs	7.5	3.9	0.0	95.1	Forest[7]
Anguilla spp. and others	x	Mkonge (mkunga)	Any type of eel	7.4	7.8	0.0	5.0	Purchased
Unknown	x	Hambo	x	5.1	5.4	0.0	71.4	Forest[7]
Scomberomorus sp. (probably *S. commerson*)	x	Nguru	Kingfish	4.2	2.3	0.0	26.1	Purchased
Unknown	x	Msusa	x	4.0	2.3	0.0	36.4	Purchased
Unknown	x	Mangaa	x	3.1	0.0	0.0	100	Forest[7]
Unknown	x	Kamba	May be lobster or crayfish	2.4	0.8	0.0	100	Forest[7]
Unknown	x	Gombe	x	1.5	0.0	0.0	25.0	Purchased
Birds								
Numida meleagris	x	Kanga	Guinea fowl, helmet	1.1	0.0	0.0	100	Forest
Pycnonotus spp.	x	Chole	Bulbul	0.7	0.8	0.0	100	Forest
Ploceus spp.	x	Nofi	Weaver, yellow	0.6	0.0	0.0	100	Forest
Quelea and other	x	Ntaa	Weaver, brown	0.4	1.2	0.0	100	Forest
Turaco fisheri and others	x	Huvi	Turaco, likely Fisher's	0.4	0.0	0.0	100	Forest
Spermestes spp.	x	Mtongo	Manikins	0.4	0.0	0.0	100	Forest

Numida guttera	x	Kororo	Crested guinea Fowl	0.4	0.0	0.0	100	Forest
Many sp/genera	x	Msozi	Mostly sunbirds	0.2	0.8	0.0	100	Forest
Turtur spp.	x	Pugi	Wood dove	0.2	0.0	0.0	100	Forest
Quelea and other	x	Nkuya (kuya)	Weaver birds	0.0	0.8	*x*	*x*	x
Colius spp.	x	Pasa	Mouse bird	0.0	0.4	*x*	*x*	x
Mammals								
Thryonomys spp.	x	Ndezi	Cane rat	3.5	1.6	10.5	68.4	Forest
Rhynchotragus spp., *Neotragus* spp. or other small antelope	x	Paa/digi-digi	Dik dik, suni, or other small antelope	0.7	0.0	0.0	100	Forest
Cricetomys gambianus	x	Kuhe	Giant pouch rat	0.7	0.0	0.0	50.0	Forest
Cephalophus spp. or *Neotragus* spp.	x	Funo	Duiker or suni	0.6	0.0	0.0	100	Forest
Colobus abyssinicus	x	Mbegha	Collobus monkey	0.0	0.8	*x*	*x*	x

*Species are listed in order of most commonly consumed (from the largest to lowest percentage of individuals consuming them—for both seasons).

[1]Identification, when marked x was obtained using the local, vernacular Swahili or Shambaa name and the literature (Harkonen et al. 2003; Harkonen and Vainio-Mattila 1998; Leonard et al. 2010; Moreau 1940, Woodcock 1995), also Patrick Maundu and Victor Mkongewa).

[2] $N = 269$ for the wet season (for mothers and children combined).

[3] $N = 129$ for the dry season (for mothers and children combined).

[4] Food items which were obtained from the forest < 10% of the time are in boldface.

[5]Most commonly reported source; “forest” includes bush (*pori*), river or other uncultivated land.

[6] Mostly the cultivated varieties are consumed, not included in calculation of percent of diet or nutrients from wild foods.

[7] Counted as two different food items on the food-use questionnaire and calculation of contribution of wild foods.

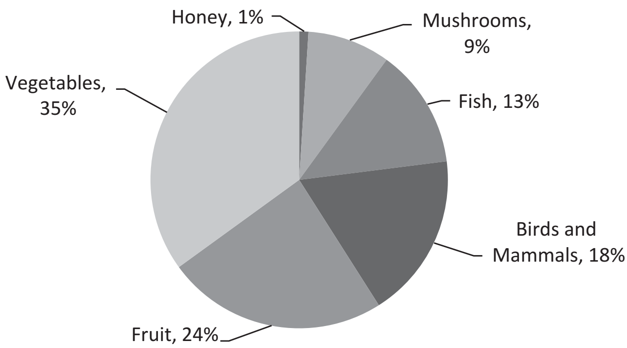

FIGURE 2 Types of wild food species used (as percent out of the 92 total species).

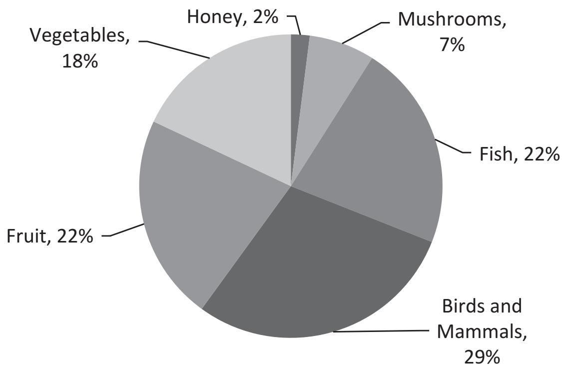

FIGURE 3 Types of foods obtained from forest (of the 45 obtained from the forest at least 10% of the time).

week (34% had consumed chicken and 32% had consumed beef). Important animal source foods from the forest in the local food system included *kanga* (Guinea fowl, *Numida meleagris*) and *ndezi* (*Thryonomys* spp., cane rat). Although, 3.5% of individuals reported consuming the latter in the last week, in fact, many were ashamed to admit eating this food. Hunters in the most remote village of our survey (Kwatango) still obtained wild pigs, but they report only one per year for the entire village of over 800 people. All species of wild birds and small mammals (two species of rodent and two species of small antelope) consumed were reported to have been obtained from the forest or bush (*pori*) the majority of the time, although small rodents were occasionally captured on farm land as well. Fish (such as *kambale, ningu, kaa*, and *magonyoo*) obtained from the river were another commonly consumed type of wild food (figure 4).

Of the total 38 varieties of fruit consumed (in the wet season) 22 were wild species (or spontaneous/escaped species; table 1 and table 2). Of these, 10 were occasionally obtained in the forest or bush and 4 were primarily obtained from the forest or bush (figure 4). Examples of fruits obtained

TABLE 2 Percent of Each Food Type Obtained from All Wild Species and Those Specifically from the Forests (for Mothers and Children, Wet Season Only)

Source	Mother (n = 269) Mean ± *SD*	Child (n = 269) Mean ± *SD*
All wild species		
Vegetables* (%)	48.3 ± 15.5	47.7 ± 16.3
Fruit (%)	20.9 ± 22.3	22.5 ± 22.8
Animal and birds (%)	3.6 ± 15.8	3.8 ± 15.6
Forest		
Vegetables* (%)	1.0 ± 4.8	1.0 ± 4.8
Fruit (%)	1.5 ± 6.8	1.7 ± 8.4
Animal and birds (%)	2.5 ± 12.1	2.8 ± 12.8
Forest and river		
Fish (%)	11.6 ± 20.1	10.8 ± 19.5

*Vegetables here include leafy and non-leafy vegetables as well as mushrooms.

FIGURE 4 Left: A boy's fresh catch of *kaa*, and *magonyoo* (Tongwe village). Right: *Dodoki* obtained from the road-side (Tongwe village; color figure available online).

from the forest included *mkimgwina* (*Sorindeia madagascariensis*), *mviru* (*Vangueria infausta* var *rotundata*) and *ngobe* (*Vitex payos* var *payos*) all of which were highly prized and widely eaten during their short seasons.

The forest was not an important site for the procurement of vegetables (table 2). Even *msangani* (*Dioscorephyllum volkensii*), often cited as the most important forest vegetable, was obtained from farmland 67.7% of the time. Although 31 of the total 44 varieties of leafy vegetables consumed were wild species, none primarily and only 18 occasionally, were collected from the forest. However, much of the farmland in the study area has significant tree cover. Moreover, a number of tree-cover dependant species were known as "forest vegetables," including *msagani, ndelema* (*Basella alba*) and *talata* (*Ipomoea* spp.), and were highly valued and culturally important. Research revealed a strong cultural preference for bitter taste and slimy texture in side dishes. These can be provided by an array of culturally-important vegetables, both cultivated and wild. The most important bitter vegetables included *ngogwe* (African eggplant, *Solanum macrocarpon*, cultivated), *mnavu* (*Solanum* spp.) and *mchunga* (*Launaea cornuta*); common slimy vegetables included *bamia* (okra, *Abelmoschus esculentus*, cultivated), *kibwando* (*Corchorus* spp.) and *ndelmea* (*Basella alba*; table 1). When time and resources permit, both a bitter and a slimy side dish are served simultaneously. Cultivated okra and African eggplants were widely traded and among the few food items sold door-to-door. *Mchunga* (which gets its name from the Kiswahili and Kisambaa word "bitter"), the quintessential bitter vegetable, consumed by over 70% of individuals in the previous week, is a culturally-important wild species obtained primarily from fields and disturbed areas. The knowledge needed for its proper preparation is a key sociocultural aspect of the traditional Wasambaa food system (Powell et al. 2010). *Kibwando*, consumed by almost 60% of individuals, grows as a weed in fields and disturbed areas. *Ndelema* was sometimes cultivated and other times collected in forests during trips to obtain firewood.

Seasonal Differences in Contribution of Wild Food from Farm and Forest to Diet

The months of April and May were the least food secure time of year, with up to 69% of households reporting inadequate food due to dwindling food stores and limited sources of cash income. In the East Usambara Mountains, the largest harvest comes from crops planted in the long rainy season (March and April). This harvest begins in July and ends in September (Porter 2006). The *mwaka* harvest produces the majority of staple food produced by a household yearly as well as cash when the harvest is sold. Although cash crops and a smaller second harvest can also be sold for cash at other times of the year, the cash from the sale of these is often used to pay school fees and other expenses rather than to purchase foods. By the end of the cool dry season and the *mwaka* harvest, when the largest harvest had been brought in and cash crops sold, few (~3%) households reported inadequate supply of food (figure 5).

Paired *t*-tests showed no difference in mean 7-day FVS and DDS_6, between seasons, for either mothers or children. Children's 1-day FVS score was slightly higher in the dry season but there was no difference in children's 1-day DDS_6 score between seasons. Conversely, significant differences were seen between seasons in the sources of foods (table 3). In the wet season 44.6% of mothers and 45.4% of children consumed one or more foods from the forest or un-cultivated land. In the dry season significantly fewer mother consumed wild foods (31.0%) but there was no change in the number of children consuming wild foods (due to ripening of a number of important

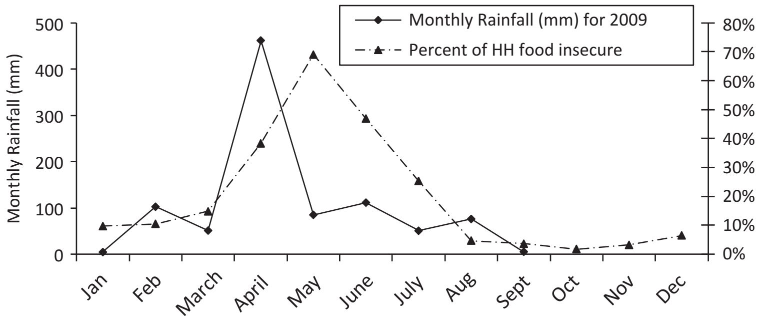

FIGURE 5 Seasonal variations in rainfall and percent of households reporting food insecurity.

TABLE 3 Seasonal Differences in Types of Foods Consumed and Sources of Foods Consumed

	Mothers (n = 129)			Children (n = 129)		
	Wet	Dry	p	Wet	Dry	p
FVS 7-day	38.1 ± 12.0	37.2 ± 12.7	NSS	39.3 ± 11.6	38.1 ± 12.7	NSS
DDS 7-day	5.55 ± 0.59	5.60 ± 0.58	NSS	5.53 ± 0.61	5.63 ± 0.56	NSS
FVS 1-day	—	—	—	9.3 ± 1.7	9.8 ± 2.4	<.05
DDS 1-day	—	—	—	3.21 ± 0.81	3.32 ± 0.94	NSS
No. wild foods used	6.0 ± 3.6	3.6 ± 3.2	<.001	6.0 ± 3.5	3.8 ± 3.1*	<.001
Wild species (%)	15.4 ± 5.4	8.7 ± 4.9	<.001	15.3 ± 5.2	9.1 ± 4.7	<.001
Purchased (%)	51.4 ± 12.9	57.3 ± 12.6	<.001	52.4 ± 12.5	57.8 ± 12.1	<.001
From farm (%)	41.6 ± 12.2	37.8 ± 12.6	<.001	40.4 ± 12.0	36.9 ± 12.0	<.001
From forest (%)	2.6 ± 0.4	1.4 ± 2.8	<.001	2.5 ± 3.7	1.8 ± 2.5	<.001
Using wild foods (%)	98.5	92.2	—	98.1	93.8	—
Using forest foods (%)	44.6	31.0*	—	45.4	45.7*	—

*Significant difference between mothers and children in dry season, likely due to consumption of seasonally available wild fruit by children.

wild fruit in the dry season, which are eaten more by children than adults). In the wet or the food insecure season, less purchased food was consumed and the percentage of the diet from wild foods from all sources and wild foods from the forest was almost double (wet: 15.4% vs. dry: 8.9% from wild species and wet: 2.6% vs. dry: 1.6% from the forest, average for mothers and children). In both seasons many of the wild species were obtained from the farm; these are removed from fields while weeding or found in field margins, fallow and agroforests, as noted by Powell and Johns (2011). This suggests that in the food insecure season local people shift to greater use of forest and wild resources, while in the dry season, when cash availability is higher, they are able to purchase a greater number of food items. Conversely, the reason for lower use of wild foods in the dry season could be in part due to reduced availability of wild vegetables, which account for a large percentage of wild food species consumed (Powell et al. 2012).

The Contribution to Nutrition of Wild Foods from Farm and Forest

The contribution of foods from each source (purchase, farm, gift, forest) to mothers' and children's intake of energy, protein, fat, vitamin C, vitamin A (RAE, retinol activity equivalents), thiamine (B_1), riboflavin (B_2), niacin (B_3), folate, calcium, iron, and zinc is presented in table 4. The majority of each of these nutrients consumed came from foods that were purchased or obtained on the farm.

The contribution of food from the farm to nutrient intake is quite different between nutrients, with as little as 32.4% and 32.7% of fat and protein and, as high as 69.8% of vitamin C, obtained from food from the farm. While wild foods contributed only 2% or total energy in the diet, they provided a greater percentage of vitamin A (RAE; 31.2%), vitamin C (20.2%) and iron (19.2%). Because wild foods from forests were consumed so infrequently, it is not surprising that they contributed less than 1% of most nutrients in the diet (from 0.33% of energy to 1.3% of protein). However, when only the days when foods from forests were consumed were considered, they made a significant contribution to most nutrients including: 39.3% of protein, 27.6% of vitamin C, 26.7 % of iron, 25.6% of vitamin A (RAE), 23.2% of calcium (second-to-last column in table 4).

Possible Determinants of Wild Food Use

To identify predictors (possible determinants) of wild food use, the percentage of children's diet from wild food (wet season) was tested against economic and environmental factors. Economic factors showed little association with wild food use; the negative correlation between community-based wealth rank and percent of children's diet from wild species was not significant (more wealthy have a lower percent of diet from wild food, $r = -0.105$; $p = .086$). While forest use and access were not associated with wild-food use, agriculture factors were (see Powell and Johns 2011 for associations between forest access and use, and use of wild foods from the forest only). The percent of children's diet from wild species showed a positive correlation with household crop diversity (number of crops cultivated over the past year; $r = 0.157$; $p < .01$) and hours spent in the farm over the last 3 days ($r = 0.190$; $p < .01$).

DISCUSSION

Historical Perspective

Fleuret (1979b) noted that wild leafy greens were the most common side dish in the Usambaras in the 1970s: "an integral and essential element in the diet of the Shambaa people at all seasons of the year"; that the majority

TABLE 4 Contribution of Foods from Different Sources to Nutrient Intake in Mothers and Children in the Wet Season (Mean ± *SD* for N = 274 Mothers and Children)

		Purchased (%)	Farm (%)	Gift (%)	Forest (%)	Days of forest food use only (%)	Wild species (%)
Kcal	Mothers	48.9 ± 26.9	48.9 ± 27.0	2.0 ± 5.8	0.3 ± 1.3	8.5 ± 6.3	1.5 ± 2.4
	Children	56.4 ± 23.1	40.9 ± 23.2	2.6 ± 5.8	0.4 ± 1.7	10.5 ± 6.7	2.5 ± 3.3
	AVE	52.7 ± 25.0	44.9 ± 25.1	2.3 ± 5.8	0.3 ± 1.5	9.5 ± 6.5	2.0 ± 2.9
Protein	Mothers	60.4 ± 24.8	36.6 ± 24.1	1.8 ± 5.8	1.3 ± 5.6	40.4 ± 22.9	6.7 ± 9.8
	Children	67.8 ± 21.2	28.8 ± 21.1	2.3 ± 6.4	1.4 ± 6.8	38.2 ± 28.2	8.1 ± 11.1
	AVE	64.1 ± 23.0	32.7 ± 22.6	2.1 ± 6.1	1.3 ± 6.2	39.3 ± 25.6	7.4 ± 10.4
Fat	Mothers	61.8 ± 27.3	35.6 ± 27.1	2.3 ± 7.1	0.3 ± 2.0	10.4 ± 12.8	1.8 ± 3.4
	Children	68.2 ± 25.1	29.2 ± 24.5	2.3 ± 8.1	0.3 ± 1.5	8.5 ± 8.1	2.1 ± 3.4
	AVE	65.0 ± 26.2	32.4 ± 25.8	2.3 ± 7.6	0.3 ± 1.8	9.5 ± 10.4	2.0 ± 3.4
Vitamin C	Mothers	25.2 ± 26.9	74.0 ± 83.0	4.8 ± 13.5	0.9 ± 5.2	27.7 ± 33.0	18.7 ± 27.0
	Children	27.8 ± 25.6	65.6 ± 31.6	6.7 ± 15.6	0.9 ± 5.0	27.5 ± 28.9	21.7 ± 25.7
	AVE	26.5 ± 26.3	69.8 ± 57.3	5.7 ± 14.6	0.9 ± 5.1	27.6 ± 30.9	20.2 ± 26.3
Calcium	Mothers	57.6 ± 27.7	39.8 ± 25.2	2.4 ± 7.6	0.9 ± 4.3	27.4 ± 23.2	16.4 ± 19.4
	Children	63.8 ± 24.6	33.0 ± 25.4	2.7 ± 7.0	0.8 ± 3.8	23.1 ± 19.6	15.9 ± 19.4
	AVE	60.7 ± 26.1	36.4 ± 25.3	2.5 ± 7.3	0.8 ± 4.1	23.2 ± 21.4	16.1 ± 19.4
RAE	Mothers	35.5 ± 28.9	60.2 ± 30.7	4.0 ± 11.6	0.8 ± 4.8	27.2 ± 28.7	31.9 ± 87.0
	Children	42.8 ± 40.5	55.3 ± 31.4	3.4 ± 9.8	0.8 ± 4.0	23.9 ± 22.5	30.5 ± 58.7
	AVE	39.2 ± 34.7	57.8 ± 31.1	3.7 ± 10.7	0.8 ± 4.4	25.6 ± 25.6	31.2 ± 72.8
Iron	Mothers	40.3 ± 30.5	57.0 ± 27.0	3.1 ± 8.5	0.8 ± 4.4	26.7 ± 24.9	18.2 ± 19.7
	Children	46.2 ± 25.0	50.6 ± 26.8	2.8 ± 7.1	0.9 ± 4.4	26.6 ± 23.3	20.1 ± 22.9
	AVE	43.2 ± 27.8	53.8 ± 26.9	2.9 ± 7.8	0.9 ± 4.4	26.7 ± 24.1	19.2 ± 21.3

(*Continued*)

TABLE 4 (Continued)

		Purchased (%)	Farm (%)	Gift (%)	Forest (%)	Days of forest food use only (%)	Wild species (%)
Zinc	Mothers	49.1 ± 28.2	48.9 ± 27.8	2.0 ± 6.2	0.5 ± 2.7	16.6 ± 14.8	4.0 ± 5.19
	Children	56.3 ± 24.3	40.9 ± 24.4	2.5 ± 6.7	0.6 ± 2.9	17.3 ± 14.1	5.4 ± 6.6
	AVE	52.7 ± 26.3	44.9 ± 26.1	2.3 ± 6.5	0.6 ± 2.8	17.0 ± 14.4	4.7 ± 5.9
Thiamine	Mothers	41.2 ± 29.6	57.0 ± 29.6	2.2 ± 6.4	0.3 ± 1.5	9.6 ± 8.2	3.7 ± 5.26
	Children	47.3 ± 26.0	49.1 ± 26.3	3.3 ± 7.4	0.5 ± 2.1	13.2 ± 9.6	5.2 ± 7.1
	AVE	44.3 ± 27.8	53.1 ± 27.9	2.8 ± 6.9	0.4 ± 1.8	11.4 ± 8.9	4.5 ± 6.2
Riboflavin	Mothers	43.2 ± 24.9	53.9 ± 25.1	2.4 ± 6.35	0.7 ± 3.4	21.9 ± 17.1	11.2 ± 13.8
	Children	49.3 ± 22.8	47.1 ± 23.2	3.0 ± 6.79	0.8 ± 3.6	22.6 ± 16.3	13.9 ± 17.2
	AVE	46.3 ± 23.8	50.5 ± 24.2	2.7 ± 6.57	0.8 ± 3.5	22.2 ± 16.7	12.5 ± 15.5
Niacin	Mothers	44.5 ± 27.6	52.9 ± 27.4	2.1 ± 6.34	1.0 ± 4.7	33.6 ± 19.8	4.7 ± 8.0
	Children	51.6 ± 23.2	44.5 ± 23.6	2.9 ± 7.04	1.4 ± 6.1	35.1 ± 23.2	6.9 ± 10.1
	AVE	48.1 ± 25.4	48.7 ± 25.5	2.5 ± 6.69	1.2 ± 5.4	34.3 ± 21.5	5.8 ± 9.1
Folate	Mothers	42.9 ± 27.0	54.4 ± 26.57	2.9 ± 7.39	0.7 ± 3.6	22.9 ± 18.8	10.4 ± 13.1
	Children	46.8 ± 23.8	49.1 ± 24.73	3.7 ± 8.64	0.9 ± 4.3	25.5 ± 19.5	13.3 ± 16.15
	AVE	44.8 ± 25.4	51.7 ± 25.65	3.3 ± 8.02	0.8 ± 4.0	24.2 ± 19.2	11.9 ± 14.6

of leafy vegetables consumed were wild; and, that exotic vegetables were not replacing the traditional wild ones. She concluded that this was in part due to better affordability, the cultural importance and the preferred taste of traditional vegetables. Much of this appears to be true in the East Usambaran food system today, although data on consumption levels were not comparable between studies. Feierman (1974) wrote in depth about the culinary and cultural importance of wild pigs to the Shambaa people. Today wild pig remains a highly esteemed food; however, they have become extremely scarce (Powell et al. 2010).

Findings in Relation to Other Studies

While many studies describe the importance of wild foods in local food systems, or report consumption of wild foods (especially leafy vegetables) or their nutrient composition, few assess the contribution of such foods to nutrient intake, in part due to methodological constraints (Chweya and Eyzaguirre 1999).

Herein we report no difference in 1-day DDS_6, 7-day DDS_6, and 7-day FVS between seasons, but significantly higher 1-day FVS in children in the dry (food plenty) season as compared to the wet (food insecure) season. Only a few other studies describe seasonal differences in dietary diversity; our findings match findings reported by Ferguson and colleagues (1993) of higher 1-day FVS (number of foods) in the season of food plenty in Malawi and Ghana but not those reported by Savy and colleagues (2006) of higher 1-day DDS in the food plenty seasons compared to the food scarce season in Burkina Faso. In Burkina Faso the higher 1 day DDS in the food plenty season was linked to higher use of purchased foods (as well as higher use of legumes and vegetables, specifically okra which ripens in the food plenty period) (Savy et al. 2006). It seems likely that in the East Usambara Mountains, increased use of wild foods in general and wild foods from the forest specifically is a strategy which allows local people to maintain their dietary diversity during the period of food shortage (to counter-balance lower access to purchased foods due to lower agricultural incomes). Wild food use was higher in the rainy season, when food was scarce, than in the dry season. Although wild foods are considered to be more available in the wet season in the East Usambara Mountains and throughout most parts of East Africa, we conclude that the lower use of wild food in the dry season was at least in part due to lower need. Similarly, Weinberger and Swai (2006) reported that diversity of traditional vegetable use was highest (while overall food diversity was lower) among the poorest households in their multi-site study in Tanzania (many of the traditional vegetables in their study were wild, and many of the wild foods in our study were "traditional vegetables"). Although findings of seasonal differences in wild food use vary between studies and regions, most are consistent with our findings: Humphry and colleagues (1993) noted that 83% of informants in Niger said their reliance on wild foods increased during drought, and Moreno-Black and Somnasang (2000) reported higher wild food usage in Thailand in the food scarce season, despite the fact that this it is also the season when wild foods are less available.

Studies, especially in North America, have compared contributions of traditional versus market foods to diet and nutrient intake of Indigenous peoples (Kuhnlein 2009). For example, in the diet of Inuit women aged 20–40 years on Baffin Island, traditional foods (mostly wild sea and land mammals, birds and fish) contributed approximately 29% of energy, 62% of protein, 57% of vitamin A, 81% of iron, 67% of zinc, and 11% of calcium intake (Kuhnlein, Soueida, and Receveur 1996). However, while most traditional foods reported are wild, different definitions of market/purchased foods and traditional / wild foods make comparison between our findings and this extensive body of research difficult.

A study in the Mekong Delta and forested Central Highlands of Vietnam is, to our knowledge, the only published work which specifically reports the contribution of wild foods to the intake of different nutrients (Ogle, Hung, and Tuyet 2001; Ogle et al. 2003). The Central Highlands site is more ecologically similar to the East Usambaras, although the contribution of wild foods to nutrient intake was higher in the Mekong Delta. Although our data included all wild foods (the majority of which were vegetables), while those from Vietnam include only vegetables, the results from Vietnam are quite similar to those from the East Usambaras. Wild foods contributed 31% of the vitamin A (RAE) in our study, and likewise wild vegetables made the greatest contribution to carotene intake in Vietnam (providing 19% in the Central Highlands). The second and third highest contribution to intake from wild foods was for vitamin C (20%) and iron (19%) in our study; in the Central Highland of Vietnam wild vegetables provided 13% of vitamin C and 14% of iron intake. In both sites the contribution of wild foods to the intake of other nutrients was lower (for example wild foods made limited contribution to zinc and niacin intake).

A body of anthropological work has examined the efficiency of different subsistence strategies for the procurement of energy and protein following optimal foraging theory paradigms (Keegan 1986; Rappaport 1968). This body of work has reported that in most horticultural and agricultural societies farming activities provide the large majority of energy, but that hunting and fishing provide the majority of protein consumed. For example, the Yassa, Mvae, and Bakola of Cameroon obtained 80% of their energy through cultivation and 70%–80% of their protein from hunting and fishing in local forests and rivers (Koppert et al. 1993). Johnson and Behrens (1982) expanded this approach to examine micronutrients and suggested that since protein is rarely the limiting nutrient in the diet, hunting and gathering was in fact more important for the provision of micronutrients (especially vitamin A, riboflavin and niacin) than protein for the Machiguenga of South America. Our more recent demonstration, that wild foods from both farm and forest make a greater contribution to the intake of many micronutrients than to that of energy and protein, supports this hypothesis.

The limited use of wild foods from forests reported here differs from other settings. For example, in Venezuela, Melnyk and Bell (1996) cite "a great dependence of Huottuja livelihoods on the forest from which they obtain more food than they would have been able to buy if they invested the same amount of time in wage labor." However, the types of foods obtained from the forest in the East Usambaras were similar to those reported elsewhere. For example in Thailand, of the food species obtained from the forest, 9% were fruits, 34% were vegetables, 5% were bamboo, 13% were mushrooms, and 39% were animal species (Vinceti et al. 2008).

CONCLUSION

The results herein highlight the importance of agricultural land and participation for the procurement and use of wild foods. Wild foods from agricultural land make a larger contribution to the diet than wild foods obtained in the forest. Possible explanations for the limited use and contribution to nutrition of foods from the forest include: ecological requirements of the most commonly consumed wild foods; cultural preference for wild foods from agricultural land; limited access due to deforestation, the time needed to travel to the forest to obtain foods and, present and historical forest governance policies and practices (Arnold et al. 2011; Woodcock 1995). Nevertheless, our data suggest that on days when foods from the forest are consumed, they contribute between 10% and 34% of the intake of various nutrients.

Because they contribute more to certain micronutrients than to energy intake, the importance of wild foods may be overlooked in studies which examine only energy intake (such as much food security research). In our study population, limiting nutrients (i.e., those most likely to be deficient) in the diet were likely: zinc, vitamin B_{12}, vitamin A, calcium and iron (Powell 2012; Appendix 5). Wild foods contributed 16% of overall calcium intake, 31% of vitamin A intake, and 19.2% or iron intake. Moreover, our findings show that wild foods were more important in the food scarce season, suggesting that need, rather than availability alone, is an important driver of wild food use in the wet season. However, we also show greater engagement in agriculture is associated with greater use of wild foods, suggesting that access is also an important factor.

Clearly, there is need for attention to the role of wild foods from farm and forest in the diets of local populations across research disciplines and administrative sectors, including (1) forestry and biodiversity conservation,

(2) agriculture, (3) public health and nutrition, and (4) education. Biodiversity conservation science and practice seek to better integrate local people into ecosystem and biodiversity management. In Tanzania, this approach has been embraced, and the country is considered exemplary for its progressive, pro-people, pro-poor forest governance policies. These policies that are meant to provide local communities with greater access to and control over forest resources needed for their livelihoods, have important implications for the food security and nutrition.

ACKNOWLEDGMENTS

Firstly we need to thank the local people of Bombani, Tongwe, Kiwanda, Kwatango, Shambangeda and Misalai for their good information and patience throughout tedious dietary intake interviews. Thank you to the field research team and local leaders for their hard work and support. Thanks also to Simon Mathenge for his excellent expert help with plant specimen identification, colleagues at Bioversity International in Nairobi and The World Vegetable Center in Arusha, and to Louise Johnson-Down for her technical support with nutrient intake analysis. Thank you also to two anonymous reviewers for their comments that helped to improve the manuscript. This research received financial support from IDRC (Canada), NSERC (Canada) and Swiss Aid through the ICRAF-CIFOR (World Agroforestry Center and Center for International Forestry Research) Landscape Mosaics project.

REFERENCES

Arnold, J. E. M., B. Powell, P. Shanley, and T. C. H. Sunderland. 2011. Forests, biodiversity and food security. *International Forestry Review* 13 (3): 259–264.

Batal, M., and E. Hunter. 2007. Traditional Lebanese recipes based on wild plants: An answer to diet simplification? *Food & Nutrition Bulletin* 28 (suppl. 2): 303S–311S.

Beasley, N. M. R., A. Hall, A. M. Tomkins, C. Donnelly, P. Ntimbwa, J. Kivuga, C. M. Kihamia, W. Lorri, and D. A. P. Bundy. 2000. The health of enrolled and non enrolled children of school age in Tanga, Tanzania. *Acta Tropica* 76:223–229.

Bharucha, Z., and J. Pretty. 2010. The roles and values of wild foods in agricultural systems. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1554): 2913–2926.

Burgess, N. D., T. M. Butynski, N. J. Cordeiro, N. H. Doggart, J. Fjeldsa, K. M. Howell, F. B. Kilahama, et al. 2007. The biological importance of the Eastern Arc Mountains of Tanzania and Kenya. *Biological Conservation* 134:209–231.

Butler, C. 2008. Human health and forests: An overview. In *Human health and forests: A global overview of issues, practice and policy*, ed., C. J. P. Colfer, 13–33. London: Earthscan.

Chweya, J. A., and P. B. Eyzaguirre. 1999. *The biodiversity of traditional leafy vegetables*. Rome, Italy: International Plant Genetic Resource Institute.

Colfer, C. J. P. 2008. *Human health and forests: Global overview of issues, practice and policy*. London: Earthscan.

Colfer, C. J. P., D. Sheil, D. Kaimowitz, and M. Kishi. 2006. Forests and human health in the tropics: Some important connections. *Unasylva* 224 (57): 3–10.

Delang, C. 2006. Not just minor forest products: The economic rationale for the consumption of wild food plants by subsistence farmers. *Ecological Economics* 59 (1): 64–73.

Dewi, S., and A. Ekadinata. 2010. Landscape dynamics over time and space from ecological perspective. Working paper number 103. Bogor, Indonesia: The World Agroforestry Center (ICRAF).

Etkin, N. L. 1994. *Eating on the wild side: The pharmacologic, ecologic, and social implications of using noncultigens*. Tucson: University of Arizona Press.

Fa, J. E., D. Currie, and J. Meeuwig. 2003. Bushmeat and food security in the Congo Basin: Linkages between wildlife and people's future. *Environmental Conservation* 30 (1): 71–78.

Falconer, J. 1990. "Hungry season" food from the forest. *Unasylva* 41 (160): 14–19.

Feierman, S. 1974. *The Shambaa kingdom*. Madison: The University of Wisconson Press.

Ferguson, E., R. Gibson, C. Opare-Obisaw, C. Osei-Opare, C. Lamba, and S. Ounpuu. 1993. Seasonal food consumption patterns and dietary diversity of rural preschool Ghanaian and Malawian children. *Ecology of Food and Nutrition* 29:219–234.

Fleuret, A. 1979a. Methods for evaluation of the role of fruits and wild greens in Sambaa diet: A case study. *Medicinal Anthropology* 3:249–269.

Fleuret, A. 1979b. The role of wild foliage plants in the diet: A case study from Lushoto, Tanzania. *Ecology of Food and Nutrition* 8:87–93.

Godin, G. 2007. CANDAT. London ON, Canada: Godin London Incorporated.

Golden, C. D., L. C. H. Fernald, J. S. Brashares, B. J. R. Rasolofoniaina, and C. Kremen. 2011. Benefits of wildlife consumption to child nutrition in a biodiversity hotspot. *Proceedings of the National Academy of Sciences* 108 (49): 19653–19656.

Grivetti, L. E., and B. M. Ogle. 2000. Value of traditional foods in meeting macro- and micronutrient need: The wild plant connection. *Nutrition Research Reviews* 13:31–46.

Hall, J. M., T. W. Gillespie, and M. Mwangoka. 2011. Comparison of agroforests and protected forests in the East Usambara Mountains, Tanzania. *Environmental Management* 48 (2): 237–247.

Herzog, F., Z. Farah, and R. Amadò. 1994. Composition and consumption of gathered wild fruits in the V-Baoulé, Côte d'Ivoire. *Ecology of Food and Nutrition* 32 (3–4): 181–196.

Humphry, C. M., M. S. Clegg, C. L. Keen, and L. E. Grivetti. 1993. Food diversity and drought survival: The Hausa example. *International Journal of Food Sciences and Nutrition* 44 (1): 1–16.

Johns, T., and P. Maundu. 2006. Forest biodiversity, nutrition and population health in market-oriented food systems. *Unasylva* 224 (57): 34–40.

Johnson, A., and C. A. Behrens. 1982. Nutritional criteria in Machiguenga food production decisions: A linear-programming analysis. *Human Ecology* 10 (2): 167–189.

Keding, G., K. Weinberger, I. Swai, and H. Mndinga. 2007. Diversity, traits and use of traditional vegetables in Tanzania, Technical Bulletin No. 40. Shanhua, Taiwan: AVRDC, The World Vegetable Center.

Keegan, W. F. 1986. The optimal foraging analysis of horticultural production. *American Anthropologist* 88 (1): 92–107.

Koppert, G. J. A., E. Dounias, A. Froment, and P. Pasquet. 1993. Food consumption in three forest populations of the southern coastal areas of Cameroon: Yassa - Mvae - Bakola. In *Tropical forests, people and food: Biocultural ineractions and applications to development*, ed., C. M. Hladik, A. Hladik, O. F. Linares, H. Pagezy, A. Semple, and M. Hadley. Man and the Biosphere series, vol. 13. Paris: UNESCO; Nashville, TN: Parthenon Publishing.

Kuhnlein, H. V. 2009. Introduction: Why are indigenous peoples' food systems important and why do they need documentation? In *Indigenous peoples' food systems: The many dimensions of culture, diversity and environment for nutrition and health*, ed., H. V. Kuhnlein, B. Erasmus, and D. Spigelski, 1–8. Rome and Montreal: Food and Agriculture Organization of the United Nations and the Center for Indigenous Peoples' Nutrition and Environment.

Kuhnlein, H. V., and O. Receveur. 1996. Dietary change and traditional food systems of indigenous peoples. *Annual Review of Nutrition* 16:417–442.

Kuhnlein, H. V., R. Soueida, and O. Receveur. 1996. Dietary nutrient profiles of Canadian Baffin Island Inuit differ by food source, season, and age. *Journal of the American Dietetic Association* 96 (2): 155–162.

Ladio, A., and M. Lozada. 2004. Patterns of use and knowledge of wild edible plants in distinct ecological environments: A case study of a Mapuche community from northwestern Patagonia. *Biodiversity and Conservation* 13 (6): 1153–1173.

Lukmanji, Z., E. Hertzmark, N. Mlingi, V. Assey, G. Ndossi, and W. Fawzi. 2008. *Tanzania food composition tables*. Dar es Salaam: Muhimbili University of Health and Allied Sciences; Tanzania: Tanzania Food and Nutrition Center; Boston: Harvard School of Public Health.

Lyimo, M., R. P. C. Temu, and J. K. Mugula. 2003. Identification and nutrient composition of indigenous vegetables of Tanzania. *Plant Foods for Human Nutrition* 58 (1): 85–92.

Maletnlema, T. N. 2002. A Tanzanian perspective on the nutrition transition and its implications for health. *Public Health Nutrition* 5 (1A): 163–168.

Maroyi, A. 2011. The gathering and consumption of wild edible plants in Nhema Communal Area, Midlands Province, Zimbabwe. *Ecology of Food and Nutrition* 50 (6): 506–525.

Melnyk, M., and N. Bell. 1996. The direct-use values of tropical moist forest foods: The Huottuja (Piaroa) Amerindians of Venezuela. *Ambio* 25 (7): 468–472.

Moreno-Black, G., and P. Somnasang. 2000. In times of plenty and times of scarcity: Nondomesticated food in north-eastern Thailand. *Ecology of Food and Nutrition* 38 (6): 563–586.

Msuya, J. M., P. Mamiro, and K. Weinberger. 2008. Iron, zinc and β-carotene nutrient potential of non-cultivated indigenous vegetables in Tanzania. In *International Symposium on Underutilized Plants*. Arusha, Tanzania: ISHS, Acta Hort.

Murphy, S. P., and L. A. Allen. 2003. Nutritional importance of animal source foods. *Journal of Nutrition* 133:3932S–3935S.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. d. Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853–858.

Nasi, R., D. Brown, D. Wilkie, E. Bennett, C. Tutin, G. van Tol, and T. Christophersen. 2008. Conservation and use of wildlife-based resources: The bushmeat crisis. Bogor: Technical Series no. 33, Secretariat of the Convention on Biological Diversity, Montreal, and Center for International Forestry Research (CIFOR).

Nordeide, M. B., A. Hatløy, M. Følling, E. Lied, and A. Oshaug. 1996. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in Southern Mali. *International Journal of Food Sciences and Nutrition* 47 (6): 455–468.

Ogle, B., P. Hung, and H. Tuyet. 2001. Significance of wild vegetables in micronutrient intakes of women in Vietnam: An analysis of food variety. *Asia Pacific Journal of Clinical Nutrition* 10 (1): 21–30.

Ogle, B. M., H. T. Tuyet, H. N. Duyet, and N. N. X. Dung. 2003. Food, feed or medicine: The multiple functions of edible wild plants in Vietnam. *Economic Botany* 57 (1): 103–117.

Pieroni, A., S. Nebel, R. F. Santoro, and M. Heinrich. 2005. Food for two seasons: Culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. *International Journal of Food Science and Nutrition* 56 (4): 245–272.

Popkin, B. M., B. Lu, and F. Zhai. 2002. Understanding the nutrition transition: Measuring rapid dietary changes in transitional countries. *Public Health Nutrition* 5 (6A): 947–953.

Porter, P. W. 2006. *Challenging nature: Local knowledge, agroscience and food security in Tanga Region, Tanzania*. Chigago: University of Chicago Press.

Powell, B. 2012. Biodiversity and human nutrition in a landscape mosaic of farms and forests in the East Usambara Mountains, Tanzania. PhD diss., School of Dietetics and Human Nutrition, McGill University.

Powell, B., J. Hall, and T. Johns. 2011. Forest cover, use and dietary intake in the East Usambara Mountains, Tanzania. *International Forestry Review* 13 (3): 305–324.

Powell, B., A. Herforth, T. Johns, and M. Oluoch. 2012. Traditional vegetables and nutrition in the East Usambara Mountains, Tanzania. Poster presentation at the International Congress of Ethnobiology, May 20–25, Montpellier, France.

Powell, B., J. Watts, A. Boucard, Z. Urech, L. Feintrenie, E. Lyimo, S. Asaha, and J. Sunderland-Groves. 2010. The role of wild species in the governance of tropical forested landscapes. In *Collaborative governance of tropical landscapes*, ed., C. J. P. Colfer and J.-L. Pfund, 157–182. London: Earthscan.

Price, L. L. 1997. Wild plant food in agricultural environments: A study of occurrence, management, and gathering rights in Northeast Thailand. *Human Organization* 56 (2): 209–221.

Rappaport, R. 1968. *Pigs for the ancestors: Ritual in the ecology of a New Guinea people*. New Haven: Yale University Press.

Ruffo, C. K., A. Birnie, and B. Tengnas. 2002. *Edible wild plants of Tanzania. Technical handbook No. 27*. Nairobi, Kenya: RELMA (at ICRAF).

Savy, M., Y. Martin-Prével, P. Traissac, S. Eymard-Duvernay, and F. Delpeuch. 2006. Dietary diversity scores and nutritional status of women change during the seasonal food shortage in rural Burkina Faso. *The Journal of Nutrition* 136 (10): 2625–2632.

Termote, C., P. Van Damme, and B. Dhed'a Djailo 2010. Eating from the Wild: Turumbu Indigenous Knowledge on Noncultivated Edible Plants, Tshopo District, DRCongo. *Ecology of Food and Nutrition* 49 (3): 173–207.

Termote, C., P. Van Damme, and B. Dhed'a Djailo 2011. Eating from the wild: Turumbu, Mbole and Bali traditional knowledge on non-cultivated edible plants, District Tshopo, DRCongo. *Genetic Resources and Crop Evolution* 58 (4): 585–618.

UN-SCN. 2004. Fifth report on the world nutrition situation. Geneva, Switzerland: United Nations, Standing Committee on Nutrition and International Food Policy Research Institute.

Vainio-Mattila, K. 2000. Wild vegetables used by the Sambaa in the East Usambara Mountains, NE Tanzania. *Annales Botanici Fennici* 37:57–67.

van Vliet, N., E. J. Milner-Gulland, F. Bousquet, M. Saqalli, and R. Nasi. 2010. Effect of small-scale heterogeneity of prey and hunter distributions on the sustainability of bushmeat hunting. *Conservation Biology* 24 (5): 1327–1337.

Vihemäki, H. 2005. Politics of participatory forest conservation: Cases from the East Usambara Mountains, Tanzania. *The Journal of Transdisciplinary Environmental Studies* 4 (2): 1–16. http://www.journal-tes.dk/vol_4_no_2/NO6_HE_l.PDF.

Vinceti, B., P. Eyzaguirre, and T. Johns. 2008. The nutritional role of forest plant foods for rural communities. In *Human health and forests: A global overview of issues, practice and policy*, ed., C. J. P. Colfer, 63–96. London: Earthscan.

Weinberger, K., and I. Swai. 2006. Consumption of traditional vegetables in central and northeastern Tanzania. *Ecology of Food and Nutrition* 45 (2): 87–103.

Willis, J. 1992. The makings of a tribe: Bondei identities and histories. *The Journal of African History* 33 (2): 191–208.

Woodcock, K. A. 1995. Indigenous knowledge and forest use: Two case studies from the East Usambaras, Tanzania. Technical Paper 22. Tanga, Tanzania: East Usambara Catchment Forest Project, Ministry of Natural Resources and Tourism, Forestry and Beekeeping Division.

Wu Leung, W. T. 1968. *Food composition table for use in Africa*. Rome, Italy: FAO.