QUANTITATIVE ASSESSMENT OF LIVELIHOODS AROUND GREAT APE RESERVES: CASES IN LUO SCIENTIFIC RESERVE, DR CONGO, AND KALINZU FOREST RESERVE, UGANDA

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ABSTRACT This study analyzed the livelihoods of people living around two great ape reserves in Africa, the Luo Scientific Reserve, Democratic Republic of the Congo, and the Kalinzu Forest Reserve, Uganda, based on quantitative assessments carried out for several years. The results show clear differences in food sources between the two sites. The forest is an important food source in Luo, whereas the market is central in Kalinzu. This difference should be acknowledged when adjusting management plans for the great ape reserves to fit the actualities of local livelihoods. For example, in Kalinzu, restricted forest use can be compensated by an increase in cash income, which is more acceptable than in Luo, where the market economy is less developed and the forest provides most of the protein consumed by local people. This difference in degree of integration into the market economy presents different challenges for the long-term management of the reserves.

Key Words: Conservation; Wildlife management; Local people; Forest resource; Rural Africa.

INTRODUCTION

African great apes, chimpanzees, bonobos, and gorillas, are regarded as flagship species for the conservation of the rainforest, as well as keystone species of their ecosystem. Because great apes move over large areas to feed and are the principal seed dispersers of many plant species, the disappearance of apes would greatly influence the species composition of the forest. Therefore, conserving great apes means at the same time conserving the forests where they live. Furthermore, as great apes seem familiar as our evolutionary cousins, their conservation has the potential to gain worldwide sympathy and substantial support.

However, there are few pristine, isolated forests anywhere in today's world. Humans live near many protected areas, including those for great apes. If we promote a conservation project without respecting the realities of local people's livelihoods, the project will be disturbed directly and indirectly by local activities and will ultimately fail. Therefore, conservation agents must understand the actual state of local people's livelihoods.

To identify conditions that are acceptable both for local people and conservation projects, many studies have examined the diet, land use, and traditional knowledge of local people in Africa. However, few quantitative and long-term assessments have been conducted regarding which resources people use and the amount of resource use in daily lives. There are several reasons for the lack of such studies. First, recording livelihoods is difficult for researchers to continue year-round. Second, if we request that people record their own livelihoods, the reliability of data may be questionable. Therefore, data collection in most anthropological and agronomic studies in rural Africa has been limited to interviews with a few informants in whom the researchers have confidence. Moreover, most studies have analyzed the frequency of occurrence of certain foodstuffs in meals, which can be recorded relatively easily, and not the weights of resources that people obtained.

However, quantitative assessments can be valuable around great ape reserves. At the study sites in the present research, we have built close relationships with local people through decades of co-research activities. In addition, we have already experienced the local diets through our stays at the research sites. Therefore, we can judge possible careless mistakes in recording as well as intentional deceptions by informants. Without such experiences, analyses of this type of data could be highly uncertain.

We conducted quantitative assessments on the diet and forest resource use of people living around five great ape reserves in Africa. Here, we present our methods and a preliminary analysis of the data obtained at two of the five research sites: the Luo Scientific Reserve, Democratic Republic of the Congo (DRC), and the Kalinzu Forest Reserve, Uganda (Fig. 1). Because our main purpose in this paper is to introduce our method of quantitative assessment, we limit our analysis to a comparison of the collective features of food procurement between the two sites. Other papers will present further analyses, such as of variations among households, seasonal changes in food procurement, and historical changes in the composition of resources and land use patterns (Kimura et al., 2012; Hashimoto et al., forthcoming).

STUDY SITE AND PEOPLE

I. Luo Scientific Reserve

The Luo Scientific Reserve is located in Tshuapa Province, DRC, and includes Wamba village (Fig. 2). The altitude ranges from 300 to 400 m above sea level, annual precipitation is about 2,900 mm, and the minimum and maximum temperatures are stable year-round between 20 and 30^{o}C (Mulavwa et al., 2008). Consequently, the land cover is lowland evergreen forest. Luo is remote from the centers of administration and national economy: 80 km from Befoli, the nearest port of passenger ships sailing up the Maringa (Luo) River, a tributary of the Congo River; 80 km from Djolu, the nearest unpaved airport for small aircraft; and 380 km from Boende, the capital of Tshuapa Province

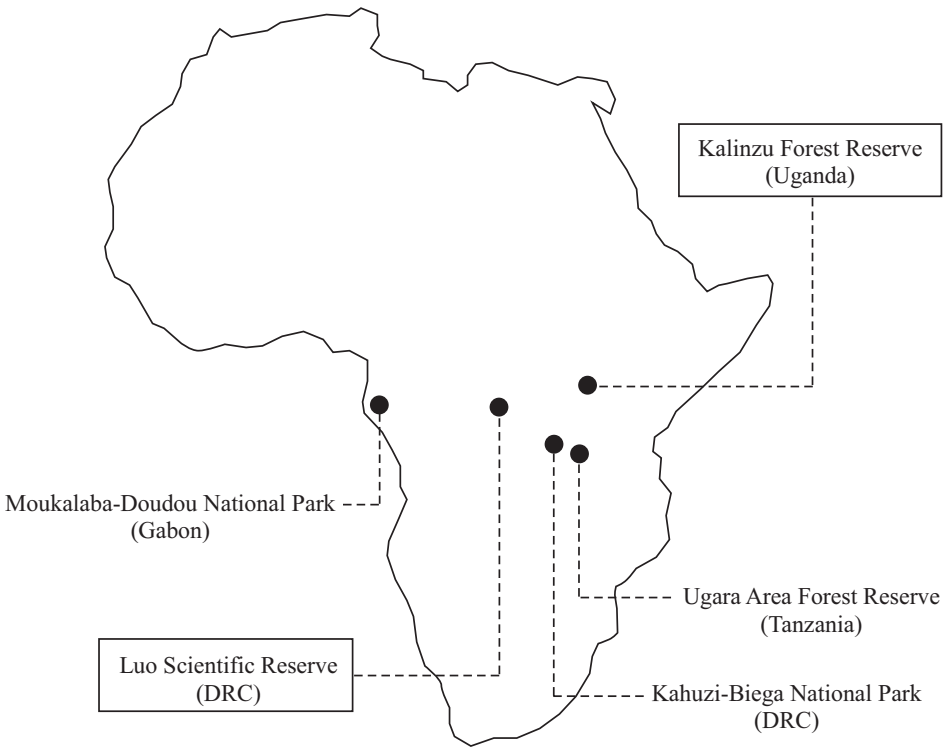

Fig. 1. Research sites. Boxes indicate the sites analyzed in this paper.

and the nearest airport with regular flights from Kinshasa. There has never been a paved road in this region. In addition, poor road maintenance during the Congo Wars in the 1990s and 2000s made transportation much more difficult than previously.

Since 1973, a Japanese research team, initially headed by Dr. Takashi Kano, has conducted bonobo (*Pan paniscus*) research based in Wamba village(1). The Luo Scientific Reserve was established in 1990 for research on and conservation of bonobo. The reserve contains settlements, fields, fallows and secondary forest, as well as mature forest. Within the reserve, it is forbidden to capture and kill primates, to hunt other animals with non-traditional methods such as with guns and metal wires, and to clear mature forest for cultivation. The long-term co-existence of human and bonobos has been acknowledged and people have not been forced to leave the reserve area(2). They continue to live and cultivate the fields within the secondary forest, even in the reserve (Kano et al., 1996; Furuichi et al., 1999). Following primate studies, research on ecological anthropology started to clarify the subsistence activities of the people living in this region (Kimura, 1992; 1998; Kimura et al., 2012; Sato, 1983; Takeda, 1990; 1996).

The Bongando are Bantu-speaking people who live in villages in this region.

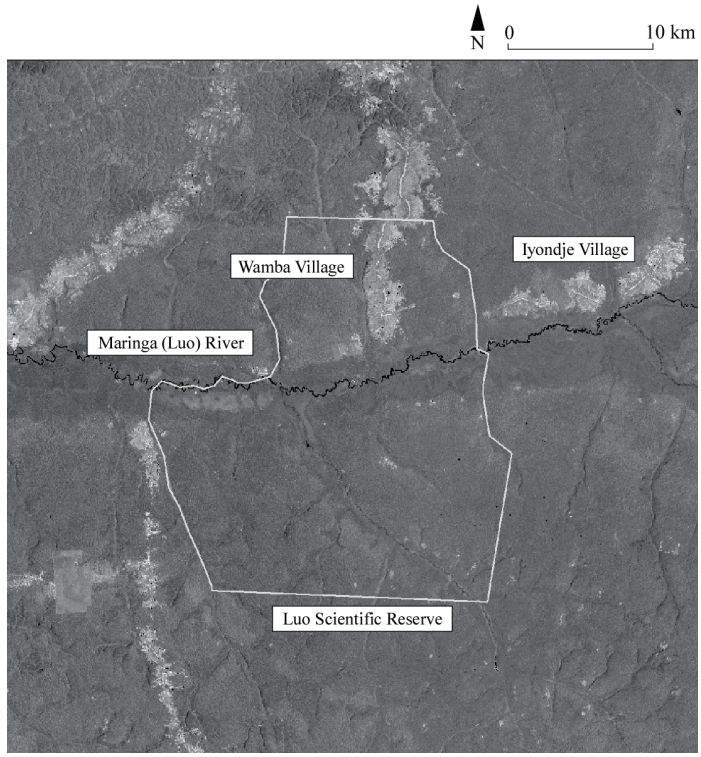

Fig. 2. Luo Scientific Reserve and its surroundings.

With a territory of 48,200 km^2 and total population estimated to be between 450,000 and 500,000 people (Kimura, 1992), the population density is about 10 persons/km^2. They speak Longando (the Bongando mother tongue) among themselves and Lingala as a lingua franca for communicating with outsiders. Their settlements are scattered along roads constructed in the 1930s by the Belgian colonial government. Crop fields, fallows and secondary forests stretch up to a few kilometers on each side of the settlements. Behind these, mature forest extends tens of kilometers to settlements along other roads. The Bongando diet is principally based on cassava. However, they also enthusiastically hunt, fish, and gather food resources. As noted by Kimura (1992), they are "multi-subsistence people" rather than "agriculturalists." Most of the Bongando live in settlements, but they sometimes stay at temporary camps for hunting and fishing (called *nkumbo* in Longando). A few people live in small, semi-permanent settlements with cassava fields (*behetsia* in Longando).

The quantitative assessment analyzed in this paper was conducted in Wamba and Iyondje, a neighboring village to the east of Wamba. Wamba village is composed of six settlements, containing 5,490 people, and Iyondje village has 10 settlements, with roughly the same population as Wamba.

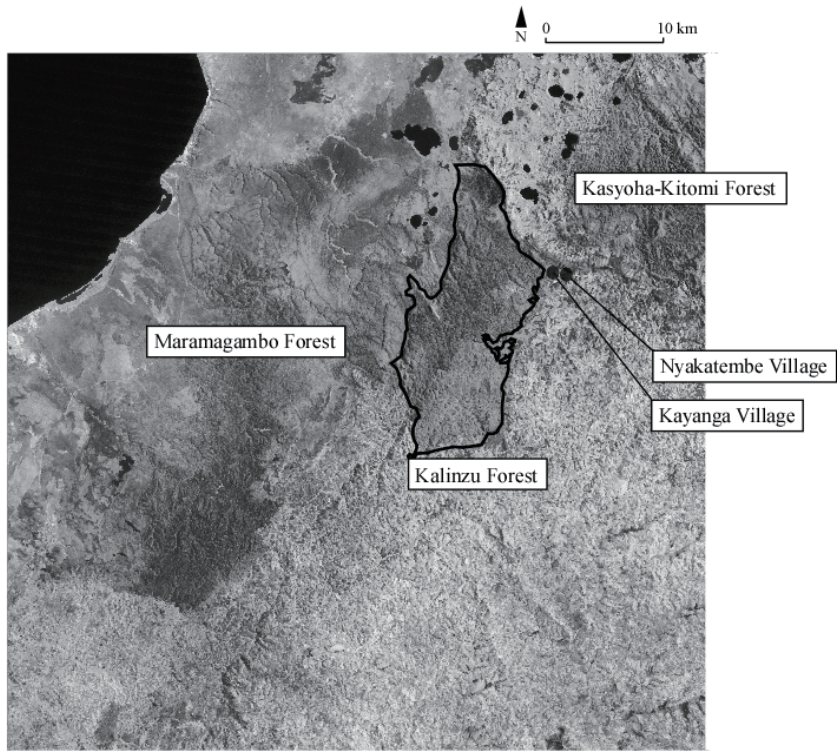

Fig. 3. Kalinzu Forest Reserve and its surroundings.

II. Kalinzu Forest Reserve

Kalinzu Forest Reserve is located on the eastern ridge of the western Rift Valley, in the western region of Uganda. A paved road of 380 km connects Kalinzu to Kampala, a journey that takes six hours by car. Kalinzu Forest covers 137 km^2 and borders the adjacent Kashoha-Kitomi Forest Reserve (399 km^2) and Maramagambo Forest Reserve (443 km^2) (Fig. 3). This area is the largest remaining forest bloc in Uganda, delimited by savanna and a lake on the north and west sides, and by agricultural fields and tea plantation to the east and south, respectively. The altitude ranges from 1,200 to 1,500 m, the annual precipitation is 1,584 mm (1997 to 1998), and the daily temperature varies from 15 to 25^{o}C year-round (Hashimoto, 1995; Furuichi et al., 2001). The vegetation is classified as medium altitude moist evergreen forest, containing deciduous trees such as *Ficus* spp. (Howard, 1991).

The Japanese primate research team began research in the Kalinzu Forest Reserve in 1992 (Hashimoto, 1995; Furuichi et al., 2001). This area currently harbors an estimated 445 chimpanzees (*Pan troglodytes troglodytes*, 3.2 animals/ km^2) and five other species of diurnal primates (Howard et al., 1996; Plumptre et al., 2008).

The Kalinzu Forest Reserve is composed of 43 compartments. Although much of the reserve has been exploited by commercial logging, well-conserved forest remains in the western and northern compartments. However, most of the northern compartments had been assigned as a timber production zone, and large-scaled selective logging started in 1998. Observing the serious damage to the forest vegetation by this logging, Japanese researchers, including ourselves, proposed the alternative use of these compartments for research and ecotourism to the Forestry Department (currently National Forestry Authority). In 2001, the Forest Department formed a joint project team with the Japanese team for research on the sustainable use of this area and conducted various research activities including stakeholder analyses in eight villages surrounding the reserve. In 2002, we completed the "Kalinzu Forest Reserve Research and Ecotourism Programme," and the Forest Department converted nine compartments in the northern area to recreation/research zones. Based on this program, the Forest Department (currently National Forestry Authority), Kalinzu Forest Project (NGO involving Japanese researchers), and Mbarara University for Science and Technology organized a steering committee and are continuing to undertake programs for the sustainable use of this area, focusing on research, ecotourism, and environmental education.

The Banyankole, another group of Bantu-speaking people, live in this region and are one of the major ethnic groups in Uganda. They live in southwestern Uganda, where the Ankole Kingdom ruled until 1967. Kalinzu forest is located in the northwestern part of the former Ankole land. Roughly a million Banaynkole live in 16,000 km^2 (Mwamwenda, 2002). The population density in the study area is estimated to be about 191 persons/km^2 according to *2002 Uganda Population and Housing Census* (Uganda Bureau of Statistics, 2002) The Banyankole consist of two major groups: the Bahima pastoralists and the Bairu agriculturists (Mwamwenda, 2002). The Bahima are politically and socially dominant even though the Bairu group is numerically larger. The groups trade goods they have produced. Their domesticated animals are predominantly cattle, along with a few goats, sheep, and chickens. The Banyankole possess large herds of a native long-horned breed of cattle that are valued for their milk and meat and are of great importance as indicators of power, wealth, and prestige (Mwamwenda, 2002). According to Mwamwenda (2002), traditional staple and favored food of the Banyankole was millet. However, today, people predominantly grow bananas as their staple food and tea as a cash crop. According to our interviews with people around the forest, they hunt only guineafowls, antelopes and bushpigs; therefore, chimpanzees and other animals are not afraid of humans.

The quantitative assessment was carried out in Kayanga and its neighboring village Nyakatembe. Kayanga is situated on the eastern border of the Kalinzu Forest, and people in this village frequently visit the forest for various purposes. Although Nyakatembe is about 1 km from the forest, people in this village also visit the forest frequently. We chose these two villages because we had built long-term relationships with the people there through providing employment for primate research since 1992.

METHODS

I. Research Period and Informants

Field data were collected from December 2005 to January 2008 around the Luo Scientific Reserve, and from November 2004 to February 2008 around the Kalinzu Forest Reserve. In Luo, 20 families in Wamba and Iyondje were selected for a one-year survey. We carried out the same investigation with 20 different households in the second year (App. 1). In Kalinzu, five households were selected for research from November 2004 to December 2005, and five households each were chosen from Kayanga and Nyakatembe from September 2006 to February 2008 (App. 2).

When we selected the informants, with the support of village chiefs, we chose average families with a person who could write in Lingala in Luo and in English in Kalinzu. In Kalinzu, where residents were engaged in a variety of jobs, we chose families for which their main income source was agriculture. We excluded households with multiple wives and over a few unmarried adults. We promised informants that we would not reveal their names in any reports and paid them a stipend slightly lower than the average salary for day laborers in the area.

II. Recording

We provided all the families with scales (spring balance with a range of 30 kg) and notebooks and requested that they record and weigh their entire daily flow of food, fuel, and other items derived from the forest including medicinal plants and building materials, and from the market. Cash flow was excluded from the data. In Luo, we gave each informants a leaflet showing examples written in Lingala (see also Kimura et al., 2012). In Kalinzu, we explained the recording formats to the chief of the village, and asked him to notify the informants of the formats, and to check the recordings (see also Hashimoto et al., forthcoming).

Although the weights of most items were recorded in kilograms, some foodstuffs were recorded by the measurement unit typically used by the informants; for example, a bundle of tomatoes, a cup of legumes, and a bunch of bananas. In such cases, we estimated the average weight of each unit recorded and converted the recorded unit to weight in kilograms. The weights of some items were recoded as “under 1 kg” because it was difficult to obtain precise weights under 1 kg with the 30 kg scale. We converted these records to 0.5 kg.

In addition to these, we asked the informants to record information about family members (sex and age of the members) who were consistently eating and sleeping in the same household, at the beginning of every month. Also, in Kalinzu, informants were asked to record information about fields (area and crop planted) and livestock (species and numbers).

III. Data Analysis

In this paper, we analyze features of collective data for all periods and informants at the respective sites, focusing on their diet. For this analysis, recorded items were categorized into two levels. The higher level consists of carbohydrate food, animal protein food, other food, and water and firewood. The lower level consists of such items as cassava, bananas, maize, fish, milk, wild mammals, and domestic animals. Seasonings, snacks, cooking oil, ready-made bottled beverages, and non-food daily commodities were recorded but excluded from analysis in this paper.

For the calculation of consumption per person, children 2 to 11 years old were counted as 0.5 and those of 0 to 1 year old were excluded from the count (Ichikawa, 1983; Kitanishi, 1995; Yasuoka, 2006). Although the recorded volume of each foodstuff includes inedible parts, we did not account for these parts because we do not yet have precise information about the ratio of edible parts among all the recorded foodstuffs. Consequently, in some cases, the consumption shown in the tables may be larger than actual consumption.

Then, we calculated the harvested amounts of each item in the lower category, sorting by the source (e.g., field, fallow, mature forest, and river). In addition, amounts of commercial deals (buying and selling) and gifting (receiving and giving) were calculated. Finally, net consumption within the households was estimated for each item in the lower category.

The major difficulty of this kind of research is that informants may falsify recordings. To avoid this, we asked reliable assistants, who have been supporting our work for a long time, to check the notebooks at least once a month. Even so, in the case of the Luo region, some informants recorded quite suspicious things; e.g., the very same things were recorded periodically. Therefore, we rigorously checked the records, and excluded doubtful informants from the analysis. We corrected clearly careless mistakes by the informants; e.g., in the case in which an informant had recorded they had sold crops without recording its harvest, we added the harvest. This case frequently occurred for cash crops such as tea and coffee.

RESULTS

I. Luo Scientific Reserve

The settlements of Wamba and Iyondje villages are scattered along roads. Roughly, settlements, fields, fallows (mixed with yourng secondary forest), and mature forest (mixed with old secondary forest) are distributed perpendicular to the road (Hashimoto et al., 1998). In addition, camps containing one to several households, surrounded by fields and fallows, are scattered in the remote forest. We classified the source of foodstuff into four categories: (1) fields, including gardens in the settlements and camps; (2) fallows, including yourng secondary forest; (3) mature forest, including old secondary forest; and (4) rivers (if

necessary).

We checked the notebooks of the informants and concluded that those of 17 out of 40 household-years were suitable for detailed analysis (nine in 2006 and eight in 2007). In this paper, we used the data obtained from January 1, 2006 to December 31, 2007 (see App. 1). The total available records for the analysis were 59,888 for 6,030 household-days. The average number of people in a household was 5.8 persons. The total number of converted adult-days for the investigation periods was 35,080.5. This number was used to calculate the amount of flow per capita per day.

(1) Carbohydrate food

Six kinds of carbohydrate food were recorded, and 74,367 kg in total, or 2.12 kg per capita per day (divided 74,367 kg by 35,080.5 adult-days), were consumed by the informants during the period (Table 1). Foodstuffs recorded were, in order of the amount of consumption, cassava, yams (domesticated species), bananas, maize, rice, and sweet potatoes. Cassava represented 85% of the total net consumption. These kinds of food were not frequently bought or sold. However, 6% of the harvest was given to others as a gift, and 9% of food consumed was received from someone else as a gift. As much as 98% of these foodstuffs were harvested from the fields, including small gardens in the settlements. In other words, the informants self-sufficiently produced their staple foods in their fields.

(2) Animal protein food

Eight categories of animal protein food were recorded, and 18,762 kg in total, or 0.535 kg per capita per day, were consumed (Table 2). Foodstuffs recorded were fish (including shellfish), wild mammals (e.g., duikers, large rodents, monkeys), insects (mostly caterpillars, i.e., larvae of Lepidoptera), wild reptiles (e.g., snakes, turtles, crocodile), domestic mammals (goats, pigs), and domestic fowls (hens, ducks). Fish made up 43% of the total, wild mammals 26%, and insects 18%. However, the harvest of caterpillars has high seasonality (Kimura et al., 2012). In contrast with carbohydrate food, 47% of the total harvests came from the river, and 37% came from mature forest. As well as carbohydrate food, the informants gave and received animal protein food as gifts: 19% of the total harvest was given to someone else, and 12% of the total consumed was received from someone else. They seldom sold these foodstuffs, although they bought 8% of the total consumed.

(3) Other food

Fourteen categories of other food were recorded, and 41,962 kg in total, or 1.20 kg per capita per day, were consumed (Table 3). Foodstuffs recorded were oil palm fruit, cassava leaf, vegetables (e.g., tomato, aubergine, pepper), forest vegetables (the pith of *Ancistrophyllum secundiflorum*, young leaves of *Leonardoxa romii*), domestic fruits (safu [*Dacryodes edulis*], pineapple, papaya, avocado, sweet banana), mushrooms, liquor, and wild fruits. Oil palm fruit made up 28% of the total consumption, followed by cassava leaf at 19%. Fields

Table 1. Harvest, commercial deal, gift, and net consumption of carbohydrate food in Luo (kg)

Food	Harvest			Commercial deal		Gift		Net consumption	
	Mature forest	Fallow	Field	Buy	Sell	In	Out	In all	Per capita per day
Cassava	144	2	61,637	592	5	3,936	6,235	60,069	1.71
Yams	23	581	4,319	21		156	391	4,709	0.134
Cooking banana		1	1,585	130		186	201	1,701	0.048
Maize	24		1,568	8		135	78	1,657	0.047
Rice		1	432	222		181	31	803	0.023
Sweet potato		1	107			4	8	103	0.003
Total	311	585	74,852	972	5	4,596	6,944	74,367	2.12

Table 2. Harvest, commercial deal, gift, and net consumption of animal protein food in Luo (kg)

Food	Harvest				Commercial deal		Gift		Net consumption	
	River	Mature forest	Fallow	Field	Buy	Sell	In	Out	In all	Per capita per day
Fish	7,278	40	54	54	713	18	1,040	1,137	8,025	0.229
Wild mammals	61	2,947	834	8	432	1	1,049	528	4,802	0.137
Insects	86	2,466	591	17	64	1	283	169	3,338	0.095
Reptiles	175	496	186	5	19		149	25	1,005	0.029
Domestic mammals			2	334	208		226	104	665	0.019
Domestic fowls				357	95	3	273	237	484	0.014
Wild birds	24	170	75	1	5		16	5	285	0.008
Eggs	1	8	1	116	11		94	73	158	0.005
Total	7,624	6,126	1,744	890	1,547	22	3,130	2,276	18,762	0.535

Table 3. Harvest, commercial deal, gift, and net consumption of other food in Luo (kg)

Food	Harvest			Commercial deal		Gift		Net consumption	
	Mature forest	Fallow	Field	Buy	Sell	In	Out	In all	Per capita per day
Oil palm	138	4,959	5,188	514	8	1,559	552	11,799	0.336
Cassava leaf	21	378	7,023	3		596	138	7,883	0.225
Vegetables	16	76	4,080	307	3	608	353	4,731	0.135
Wild leaves	3,160	525	36	307	10	237	246	4,008	0.114
Domestic fruits	54	439	2,596	97		550	159	3,577	0.102
Mushrooms	1,575	368	199	34	11	98	158	2,104	0.060
Alcoholic beverage	21	3	1,142	400	3	500	378	1,684	0.048
Wild fruits	907	709	23	32	1	132	31	1,771	0.050
Sweet banana	0	4	1,194	210		190		1,597	0.046
Palm wine	48	566	41	178		238	98	972	0.028
Coffee	18		208	496		127	86	763	0.022
Sugarcane	1		630	39		62	97	634	0.018
Honey	232	39	0	3		15		288	0.008
Medical plants	72	59	2	17		3	1	151	0.004
Total	6,260	8,124	22,361	2,634	34	4,913	2,297	41,962	1.20

Table 4. Harvest, commercial deal, gift, and net consumption of water and firewood in Luo (kg)

	Harvest				Commercial deal		Gift		Net consumption	
	River	Mature forest	Fallow	Field	Buy	Sell	In	Out	In all	Per capita per day
Water	142,097	299	134	2,661	41		1,219	3,474	142,976	4.08
Firewood	317	12,671	17,561	63,269	30		823	3,809	90,862	2.59

supplied a large part of the these food (61%), but fallows and secondary forest (22%) and mature forest (17%) cannot be ignored. As much as 6% of the harvest was given to others as a gift, and 12% of consumption was received from someone as gift. The informants seldom sold these foodstuffs, but they bought 6% of the total consumed.

(4) Water and firewood

A total of 142,976 kg in total, or 4.08 kg per capita per day, of water, and a total of 90,862 kg, or 2.59 kg per capita per day, of firewood were consumed (Table 4). Almost all of the water was taken from rivers ("forest" or "fields" in the table probably indicate springs that were near or in these areas). Most (67%) of the total harvest of firewood was taken from the fields, while 19% came from the secondary forest and 14% from mature forest. Commercial dealings over water and firewood were rare. However, 4% of the firewood harvest and 2% of water were given to others.

II. Kalinzu Forest Reserve

In the Kalinzu region, forest exists only in protected areas surrounded by agricultural land. People in this area seldom used the forest. In almost all cases, they harvested foodstuffs from their fields or gardens around their houses. Therefore, in the following tables, sources of foodstuffs are not mentioned.

We checked the notebooks of the informants and concluded that all of them were suitable for analysis. In this paper, we used the data obtained from December 1, 2004 to November 30, 2005, and from January 1 to December 31, 2007 (see App. 2). The total records available for the analysis were 34,034, for 5,247 household-days. The average number of people in a household was 5.4 persons. The total number of adult-days for the investigation periods was 28150.5.

(1) Carbohydrate food

Ten kinds of carbohydrate food were recorded, and 58,392 kg in total, or 2.07 kg per capita per day (58,392 kg divided by 28150.5 adult-days), were consumed (Table 5). Main foodstuffs recorded were, in order of the amount of consumption, cooking bananas, sweet potatoes, cassava, maize, finger millet, and taro. Among them, bananas made up 64% of the total consumption. For the top three foodstuffs (bananas, sweet potatoes, cassava), taro, and potatoes, amounts of self-production exceeded what families bought. But, for maize and

Table 5. Harvest, commercial deal, gift, and net consumption of carbohydrate food in Kalinzu (kg)

Food	Harvest	Commercial deal		Gift		Net consumption	
		Buy	Sell	In	Out	In all	Per capita per day
Cooking banana	41,407	1,273	4,918	319	662	37,420	1.33
Sweet potato	6,665	599	266	114	219	6,893	0.245
Cassava	3,715	1,036	472	201	194	4,286	0.152
Maize	706	2,278	54	114	120	2,924	0.104
Finger millet	1,359	1,428	40	241	66	2,923	0.104
Taro	3,025	27	75	14	88	2,903	0.103
Potato	331	145		12	3	485	0.017
Rice		392		2	1	393	0.014
Bread		133				133	0.005
Sorghum	10	27		5	10	32	0.001
Total	57,220	7,339	5,825	1,020	1,362	58,392	2.07

Table 6. Harvest, commercial deal, gift, and net consumption of animal protein food in Kalinzu (kg)

Food	Harvest	Commercial deal		Gift		Net consumption	
		Buy	Sell	In	Out	In all	Per capita per day
Milk	1,518	1,650	946	5	3	2,224	0.079
Beef	11	1,077	1	7	6	1,088	0.039
Fish	43	455	1	5	1	501	0.018
Domestic fowls	86	74	59	11		112	0.004
Meat (except beef)	1	95				96	0.003
Egg	27	56	8			75	0.003
Insects	3	6				9	0.000
Total	1,688	3,412	1,015	28	9	4,103	0.146

finger millets, amounts bought exceeded what they harvested from the fields. Compared to people in Luo, those in Kalinzu were much more involved in the market economy (including buying from people living in the same village): 10% of the total harvest was sold, and 13% of the total consumption was bought. Meanwhile, only 2% of the harvest was given to someone, and 2% of food consumed was received as a gift.

(2) Animal protein food

Seven categories of animal protein food were recorded, and 4,103 kg in total, or 0.146 kg per capita per day, were consumed (Table 6). Foodstuffs recorded were milk, beef, fish, domestic fowls, other meat (goat, sheep, pork, and hare), eggs, and insects (mainly grasshoppers). Milk made up 54% of the total consumption, beef made up 27%, and fish 12%. The greater part of animal protein foodstuffs (83% of the total consumed) was bought. The harvest of milk was equal to the amount bought. However, this was recorded by only one informant out of 15, who kept cows. Like for carbohydrates, it was rare to give these foodstuffs to or receive them from anyone.

Table 7. Harvest, commercial deal, gift, and net consumption of other food in Kalinzu (kg)

Food	Harvest	Commercial deal		Gift		Net consumption	
		Buy	Sell	In	Out	In all	Per capita per day
Kidney bean	2,426	1,269	218	73	148	3,403	0.121
Tomato	973	1,111	769	4	0.4	1,318	0.047
Green vegetable (*dodo*)	1,780	66	773	2	0.2	1,075	0.038
Avocado	1,486	293	885	115	0.2	1,008	0.036
Sweet banana	886	228	131	3		987	0.035
Pineapple	793	556	395	3	160	799	0.028
Cabbage	337	546	104	4	10	772	0.027
Sugarcane	653	253	179	6	13	721	0.026
Peanut	542	320	195	15	21	661	0.023
Papaya	549	32	10	2	3	570	0.020
Pumpkin	339	27		28	19	375	0.013
Aubergine	245	134	18	6	1	366	0.013
Tea	14,390	74	14,168		5	291	0.010
Jackfruit	184	88				272	0.010
Onion	44	165	18	2		194	0.007
Mango	173	26	3	4	5	195	0.007
Pea	8	181		0	3	186	0.007
Mushrooms	109	4		14	1	126	0.004
Coffee	1,873	52	1,805	60	90	90	0.003
Watermelon		67				67	0.002
Orange	6	55				60	0.002
Passion fruit	13	32				45	0.002
Soybean	39	9	10			39	0.001
Honey	16	19	3	0.0		32	0.001
Carrot		17				17	0.001
Sunflower	14				2	13	0.000
Green pepper	2	4				5	0.000
Apple	4	1				5	0.000
Cauliflower		4				4	0.000
Lemon		0.4				0.4	0.000
Total	27,885	5,632	19,682	339	479	13,695	0.486

Table 8. Harvest, commercial deal, gift, and net consumption of water and firewood in Kalinzu (kg)

	Harvest			Commercial deal		Gift		Net consumption	
	Spring	Rain, others		Buy	Sell	In	Out	In all	Per capita per day
Water	199,713	56,031		320		70		256,134	9.10
	Artificial forest	Natural forest	Field						
Firewood	18,298	13,865	388	143	250	250	150	32,544	1.16

(3) Other food

A total of 30 kinds of foodstuff, including four kinds of legumes, 10 of vegetables, 11 of fruits, two of cash crops, honey, sugarcane, and mushroom were recorded, and 13,695 kg in total, or 0.486 kg per capita per day, were consumed (Table 7). The main foodstuffs recorded were kidney beans, tomatoes, green vegetables (*dodo* in vernacular), avocados, and sweet bananas. Kidney beans made up 25% of the total consumption, or 0.121 kg per capita per day, and are an important source of protein for the people in this area. Although these foodstuffs were cultivated, 41% of the total consumed was bought in the market. Gifting of these foods was limited, as for other kinds of food. Tea and coffee were cultivated for commercial purposes and were harvested by many families, but almost all of these crops were sold.

(4) Water and firewood

As much as 256,134 kg in total, or 9.10 kg per capita per day, of water, and 32,544 kg, or 1.16 kg per capita per day, of firewood were consumed (Table 8). Most water (78%) was taken from springs (including that recorded as "from a well" because there are actually few wells in this region). Rainwater collected from tin roofs was also used. About half (56%) of the total harvest of firewood was taken from the artificial eucalyptus forest, and 43% was taken from the natural forest. In contrast to the Luo area, fields in Kalinzu did not contribute as a source of firewood because shifting cultivation was not practiced in this area. Commercial dealings in water and firewood were rare.

III. Comparison Between Luo and Kalinzu

(1) Sources of foodstuffs

As shown in Tables 1 to 8, we calculated the total harvests per capita per day for each food category, the proportion of each food source to the total harvest, the net consumption of each food category, and the proportions of amount of each item obtained by commercial dealings and gifts to the total net consumption (Tables 9 & 10).

At both research sites, people produced adequate amounts of carbohydrate food. In Luo, cassava and other foodstuffs supplied 2.12 kg per capita per day, or 1,650 kcal converted by assuming an edible ratio of 0.6 and energy value of 1.3 kcal/g. In Kalinzu, cooking bananas and other carbohydrate foods supplied 2.07 kg, or 1,615 kcal, with the same assumptions. The primary foodstuffs of cassava in Luo (85%) and bananas in Kalinzu (64%) were common in both areas (Tables 1 & 5). Meanwhile, secondary foodstuffs in Kalinzu (i.e., sweet potatoes, cassava, maize, finger millet, and taro) contributed more importantly to the diet compared to those in Luo.

In contrast with carbohydrate food, there was a large difference in the sources of animal protein food between the two sites. People in Luo hunted in the forest and fished in the river, whereas people in Kalinzu bought milk and beef at the market. In both areas, consumption of animal protein was not low. In particular, people in Luo procured 0.535 kg per capita per day (or 0.321 kg,

assuming an edible ratio of 0.6). An estimated 0.1 to 0.2 kg of animal meat is consumed per capita per day in Africa (Wilkie et al., 1999; Nasi et al., 2008). Therefore, people in Luo consumed much more animal protein food than the average[3]. In Kalinzu, people consumed 0.146 kg (mainly milk and beef), which is around the average. In addition, kidney bean consumption of 0.121 kg per capita per day (or 0.073 kg, assuming an edible ratio of 0.6) contributed largely to protein intake in Kalinzu.

Food sources were quite different between the two villages. In Luo, various land types, such as river, mature forest/old secondary forest, fallows/yourng secondary forest, as well as fields, provided foodstuffs to the people. In particular, fish from the river, wild animals, caterpillars, forest vegetables, fruits, mushrooms, honey and medicinal plants from the mature forest, and oil palm fruit, palm wine, and fruits from the fallows are notable. This result agrees with Kimura's (1992) description of the Bongando as a "multi-subsistence people." In fact, except for carbohydrate food, people in Luo consumed much more foodstuffs (1.73 kg) than people in Kalinzu (0.69 kg). In contrast, in Kalinzu, fields were almost the only food supply source other than the market. Only mushrooms and medicinal plants were taken from the forest. However, we should note that the forest was the primary source of firewood in Kalinzu, whereas fields provided much of the firewood as part of shifting cultivation in Luo.

In summary, in both villages, residents had the ability to produce their staple carbohydrate food in their own fields. However, this was not the case with other kinds of food. The forest was important in Luo, whereas the market was important in Kalinzu.

(2) Sales and gifting of products

Tables 9 & 10 show that gifts were significance for food procurement in Luo while commercial dealings were important in Kalinzu. In Luo, 10% of the total consumption was gifted from someone else. In particular, alcohol (28% of the total consumption was received as gifts), animal protein food (17%), coffee (17%), and oil palm (13%) were noteworthy as gifts. In Kalinzu, informants bought 83% of their animal protein food, 50% of vegetables, 42% of legumes, 36% of fruits, and even 13% of their carbohydrate food.

The top 10 items sold and given to someone in each site are listed in Tables 11 and 12. In Luo, there were few commercial dealings and people gifted a considerable part of their harvests to others. Cassava (10% of the total harvest was given as gifts), fish (15%), wild mammals (14%), and liquor (32%) were notable as gifts. It is also noteworthy that these foodstuffs were part of the basic diet in Luo. In Kalinzu, gifts were much less important than in Luo, and only pineapples (20%) and maize (17%) were notable gifts in terms of percentage of the total harvest. In contrast, large amounts of produce were sold. Tea (98% of the total harvest was sold), coffee (96%), milk (62%), avocados (60%), green vegetables (*dodo*) (43%), tomatoes (79%), and pineapples (50%) were notable as cash crops. In particular, selling tea contributes to obtaining animal protein foods (i.e., milk and beef), which are traditional foods, as noted

Table 9. Percentage of each harvesting area to the total harvest and percentage of bought and gift items to total net consumption in Luo

Food category	Harvest per capita per day (kg)	Percentage to the total harvest				Net consumption per capita per day (kg)	Percentage to the total net consumption	
		River	Mature forest	Fallow	Field		Buy	Gift
Carbohydrate food	2.16		0.4	1	99	2.12	1	7
Animal protein food	0.467	47	37	11	5	0.535	8	17
Vegetables & Forest leaves	0.437		21	6	73	0.474	4	9
Edible oils	0.293		1	48	50	0.336	4	13
Fruits	0.169		16	19	64	0.198	5	13
Alcoholic beverage	0.052		4	31	65	0.076	22	28
Mushrooms	0.061		74	17	9	0.060	2	5
Sugarcane & Honey	0.026		26	4	70	0.026	5	8
Coffee	0.006		8		92	0.022	65	17
Medical plants	0.004		54	44	2	0.004	11	2
Total	3.67	6	10	8	76	3.85	4	10

Table 10. Percentage of each harvesting area to the total harvest and percentage of bought and gift items to total net consumption in Kalinzu

Food category	Harvest per capita per day (kg)	Percentage to the total harvest				Net consumption per capita per day (kg)	Percentage to the total net consumption	
		Pond	Natural forest	Artificial forest	Field		Buy	Gift
Carbohydrate food	2.03				100	2.07	13	2
Legumes	0.107				100	0.152	41	2
Vegetables	0.133				100	0.147	50	1
Animal protein food	0.060	0.0	0.0	1	99	0.146	83	1
Fruits	0.145				100	0.143	34	3
Saccharide, Oil & Seasoning						0.041	100	0.0
Sugarcane & Honey	0.024				100	0.027	36	1
Tea & Coffee	0.578				100	0.014	33	16
Beverages	0.003				100	0.009	98	2
Mushrooms	0.004		91	8	1	0.004	3	10
Medical plants	0.004		87	9	4	0.002	5	
Snacks						0.001	100	
Total	3.09	0.0	0.2	0.0	100	2.76	23	2

Table 11. Top 10 products in sales and gifts in Luo (kg)

	Product	Harvest	Sold	Sold/Harvest
Sales	Fish	7,426	18	0.00
	Mushrooms	2,141	11	0.01
	Wild leaves	3,720	10	0.00
	Oil palm	10,285	8	0.00
	Cassava	61,782	5	0.00
	Domestic fowls	357	3	0.01
	Liquors	1,166	3	0.00
	Vegetables	4,172	3	0.00
	Wild fruits	1,639	1	0.00
	Insects	3,160	1	0.00
	Product	Harvest	Given	Given/Harvest
Gifts	Cassava	61,782	6,235	0.10
	Firewood	93,818	3,809	0.04
	Water	145,190	3,474	0.02
	Fish	7,426	1,137	0.15
	Oil palm	10,285	552	0.05
	Wild mammals	3,849	528	0.14
	Yams	4,923	391	0.08
	Liquors	1,166	378	0.32
	Vegetables	4,172	353	0.08
	Wild leaves	3,720	246	0.07

Table 12. Top 10 products in sales and gifts in Kalinzu (kg)

	Product	Harvest	Sold	Sold/Harvest
Sales	Tea	14,390	14,168	0.98
	Cooking banana	41,407	4,918	0.12
	Coffee	1,873	1,805	0.96
	Milk	1,518	946	0.62
	Avocado	1,486	885	0.60
	Green vegetable (*dodo*)	1,780	773	0.43
	Tomato	973	769	0.79
	Cassava	3,715	472	0.13
	Pineapple	793	395	0.50
	Sweet potato	6,665	266	0.04
	Product	Harvest	Given	Given/Harvest
Gifts	Cooking banana	41,407	662	0.02
	Sweet potato	6,665	219	0.03
	Cassava	3,715	194	0.05
	Pineapple	793	160	0.20
	Firewood	32,551	150	0.00
	Kidney bean	2,426	148	0.06
	Maize	706	120	0.17
	Coffee	1,873	90	0.05
	Taro	3,025	88	0.03
	Finger millet	1,359	66	0.05

above.

In summary, livelihood in Luo, where the gift economy is remarkable, is self-sufficient. In contrast, in Kalinzu, livelihoods are based on the intra- and inter-regional market economy, some of which is integrated into the global market, i.e., tea and coffee. Tables 11 & 12 show an interesting contrast. Bananas, the principal calorie source in Kalinzu, were sold in that area as much as cassava was gifted in Luo. This coincidence may imply the contrast in the importance of the market economy in Kalinzu and the gift economy in Luo.

IMPLICATIONS FOR CONSERVATION MANAGEMENT

We are aiming to establish management plans for great ape conservation that are adjusted to the unique situations of each reserve. Understanding the actual livelihoods of local people is crucial for developing collaborative forest resource management between the people and researchers. However, it is not easy to conduct long-term and large-scale quantitative assessments of forest resource use by local people. Although we had built close relationships with local people, half of the informants in Luo kept suspicious records(4). Even so, quantitative assessment covering more than 10 households throughout two years at each site provides valuable information about their livelihoods. In this paper, we have presented a preliminary analysis comparing two of our five study sites. We will make further analyses about variations among households, seasonal changes, and interannual fluctuations at each site, as well as comparisons among the sites. Particularly in Luo where the forest is heavily used, we need to combine the data on diet with spatial information of food procurement to examine the sustainability of the resources. In this section, we discuss some implications of the results for the management of great ape reserves.

As shown above, the importance of the forest as a food source differs substantially between Kalinzu and Luo. In addition, shifting cultivation is practiced in Luo, whereas permanent land use is practiced in Kalinzu. This may be because much forest remains in Luo, but there is only limited forest in Kalinzu (see Figs. 2 & 3). In the case of sharp population increases, fields will likely expand into mature forests in Luo, while people from Kalinzu will probably leave for cities (maybe after all the forest will be cleared in a very short period, if clearing is not prohibited). Therefore, we must consider different problems for the long-term management of the reserves.

In any case, forest regulation will have different impacts on livelihoods in the two villages. The impact will be smaller in Kalinzu where the people depend more on the market, and larger in Luo where the people depend more on the forest. In Kalinzu, it may be relatively easy to reach a consensus between the local people and conservation agencies, by providing the people with opportunities to earn cash income. In fact, ecotourism in Kalinzu is promising as an incentive for local people to protect the forest and chimpanzees. However, this is not the case in Luo. Because of transportation difficulties, ecotourism in Luo is not conceivable at present. Also, the commodity flow is limited, and

above all, we must begin to provide commodities in this region. All the profits concerning the reserve are derived from the researchers, of whom the local people have unreasonably high expectations.

Furthermore, a meta-analysis of the data recordings may imply that many people in Luo are not familiar with quantitative understanding of their own livelihoods. This means that it is difficult to give feedback on our research outcomes to the people. People in Kalinzu, who largely depend on the market, seem to have literacy of quantitative data on their own resource use. In any market, commodities are measured in numerical values. Consequently, people in Kalinzu are familiar with measuring production and consumption in their daily practices. In contrast, in Luo, the people treat foodstuffs more as gifts than as commodities. In the case of gifting, who gives is much more important than a numeric value for an item. This difference between the two sites may have contributed to the differences in the reliability and availability of the recorded data: there were no unusable records in Kalinzu, whereas 23 records out of 40 were unusable in Luo. This unfamiliarity with data recording will also create difficulties when we try to share the results of our study with people in Luo.

Finally, we should note another serious limitation of our method. We selected limited numbers of informants from a large population; however, there must be some people who use forest resources much more heavily than the average shown by our analysis. Because our ultimate goal is to not only understand the average resource use of local people, but also to carry out effective management plans of the reserve in collaboration with the local community, we should not ignore this diversity of use.

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NOTES

(1) Because of political disorder in Zaïre from 1991 and the first and second Congo Wars from 1997, research and conservation activities were discontinued until 2002 (Furuichi & Mwanza, 2003; Tashiro et al., 2007). Partly because of hunting by soldiers stationed in the area during the wars, the bonobo population has declined in the Wamba area (Furuichi, 2004).

(2) The Bongando, who live in this region, do not include bonobos in their diet (Lingomo & Kimura, 2009) and thus do not hunt bonobos.

(3) Although there are few records of meat selling, Kimura et al. (2012) found that some people go to Kisangani to sell forest products including meat and fish. However, the volume of this trade is so small that it does not affect livelihoods as Kisangani is about 500 km from the Luo area.

(4) One of the reasons may be that we could not visit Luo frequently, and thus we could not check the recordings ourselves. Checking the records at least every 2 months is preferable to discourage deception.

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Appendix 1. Monthly number of recording days for 17 informants in Luo

Year	Month	Informant																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2005	Dec	4	4	2	2	4	2	3		2								
2006	Jan	31	31	31	31	31	31	31	24	31								
	Feb	28	28	28	28	28	27	28	28	28								
	Mar	31	31	31	31	31	31	31	31	31								
	Apr	30	30	30	30	30	30	30	30	30								
	May	31	31	31	31	31	31	31	31	31								
	Jun	30	30	30	30	30	30	30	30	30								
	Jul	31	31	31	31	31	30	31	31	31								
	Aug	31	31	31	31	31	31	31	31	31								
	Sep	30	30	30	30	30	30	30	30	30								
	Oct	31	31	31	30	31	30	31	30	31								
	Nov	30	30	30	30	30	30	30	30	30								
	Dec	31	31	31	31	31	31	31	31	31								
2007	Jan		4					6			31	23	22	22			21	22
	Feb										28	17	28	28	14	15	28	28
	Mar										30	30	31	31	31	31	31	29
	Apr										30	30	29	30	30	30	30	30
	May										31	31	31	31	31	31	31	21
	Jun										30	30	30	30	29	30	29	28
	Jul										31	31	30	31	31	31	31	29
	Aug										30	31	31	31	31	31	31	31
	Sep										29	30	30	30	30	30	30	27
	Oct										31	31	30	31	31	31	31	31
	Nov										30	30	30	30	30	30	30	30
	Dec										31	31	31	31	31	31	31	31
2008	Jan													10	10		10	6
Data used for analysis		365	369	365	364	365	362	371	357	365	362	345	353	356	319	321	354	337
Total recording days		369	373	367	366	369	364	374	357	367	362	345	353	366	329	321	364	343

Boxes indicate the data used for the analysis in this paper.

Appendix 2. Monthly number of recording days for 15 informants in Kalinzu

Year	Month	Informant														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2004	Nov	15	15	15	15	15										
	Dec	31	31	31	31	31										
2005	Jan	31	31	31	31	31										
	Feb	28	28	28	28	28										
	Mar	31	31	31	31	31										
	Apr	30	30	30	30	30										
	May	31	31	31	31	31										
	Jun	30	30	30	30	30										
	Jul	31	31	31	31	31										
	Aug	31	31	31	31	31										
	Sep	30	30	30	30	30										
	Oct	31	31	31	31	31										
	Nov	30	30	30	30	30										
	Dec	4	4	4	4	31										
2006	Sep						9	7		7	7	7	7	7	7	7
	Oct						31	31		31	31	31	31	31	31	31
	Nov						30	30		30	30	30	30	30	30	30
	Dec						31	31		31	31	31	31	31	31	31
2007	Jan						31	31	31	31	31	31	31	31	31	31
	Feb						28	28	28	28	28	28	28	28	28	28
	Mar						31	31	31	31	31	31	31	31	31	31
	Apr						30	30	30	30	30	30	30	30	30	30
	May						31	31	31	31	16	29	31	31	31	31
	Jun						30	30	30	30			30	30	30	30
	Jul						31	31	31	31			31	31	31	31
	Aug						31	31	31	31			31	31	31	31
	Sep						30	30	30	30	15	18	30	30	30	30
	Oct						31	31	31	31	31	31	31	31	31	31
	Nov						30	30	30	30	30	30	30	30	30	30
	Dec						31	31	31	31	31	31	31	31	31	31
2008	Jan											31		4	4	4
	Feb											15				
Data used for analysis		365	365	365	365	365	365	365	365	365	243	259	365	365	365	365
Total recording days		384	384	384	384	411	466	464	365	464	342	404	464	468	468	468

Boxes indicate the data used for the analysis in this paper. Notebooks in which Nos. 10 & 11 recorded from mid-May to mid-September were lost by accident.