THE MANAGEMENT OF WILD YAM TUBERS BY THE BAKA PYGMIES IN SOUTHERN CAMEROON

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ABSTRACT Wild yams (*Dioscorea* spp.) are primordial sources of carbohydrates for many hunter-gatherers of African forests. Yams play a key role in the symbolic perception of the forest by the Baka Pygmies of Southern Cameroon. The Baka have elaborated an original form of wild yam exploitation that I have termed "paracultivation". Paracultivation defines a set of technical, social and cultural practices aiming at managing wild resources while keeping them in their natural environment.

In 1994, I undertook an experimental survey to estimate the effect of paracultivation on survivol and growth of yam plants. Preliminary results presented here demonstrate that paracultivation increases the production of tubers without affecting plant survivorship. Furthermore, it allows a better control of the spatial and temporal availability of yam resources by the Baka.

This study has opened up new perspectives on the evolutionary ecology of tuber-producing tropical forest plants. Paracultivation encourages us to reconsider the interactive process between forest dwellers and their environment.

Key Words: Wild yams; Baka; South Cameroon forest; Paracultivation; Resource management; Ethnoecology

INTRODUCTION

I. Protocultivation: A Step to Domestication

Historical studies of the processes of plant domestication were long dominated by Judeo-Christian bias, persisting in locating the birthplace of the agricultural revolution in the "fertile crescent" of the Near East. The rise of agricultural civilisations could not be conceived of without seeds. Only in the 1970's did scientists divorce with classical schemes the emergence of agriculture, by describing the age-old agricultural prehistory which preceded the domestication of barley and wheat by many civilizations in other parts of the world (Harlan et al., 1976; Harris & Hillman, 1989). Interest progressively focused on the Indo-pacific domain, both as the center of origin of a wide range of cultivated plants but also as an ancient locus of domestication. In his innovative work on Melanesia, Barrau (1970) insisted on the interest of analyzing the processes of wild yam harvesting as a demonstration of the major role of vegetative propagation in the domestication of starch-rich perennial crops, which are clonally reproduced. Up to now the observation of such practices among persisting hunting and gathering societies has been generally motivated by the attempt to reconstruct the transition to agriculture in prehistory.

The maintenance of wild-yam tuber heads in soil, or their reburial after harvesting of the fleshy parts, are fairly common practices among hunter-gatherers. I described such practices for the Kubu of Sumatra (Dounias, 1989; submitted), but it is also mentioned in Malaysia among the Orang Asli (Rambo, 1979) and the Batek De' (Endicott & Bellwood, 1991); in the Philippines among the Batak (Eder, 1988) and the Tasaday (Yen, 1976); in Papua New Guinea (Yen, 1989); in Thailand among the Hoabinhian (Yen, 1977); in India among the Chenchu of the Krishna River (Furer-Haimendorf, 1943); in various locations and ethnic groups in Australia (Grey, 1841; Jones, 1975; Jones & Meehan, 1989; Yen, 1989; Hallam, 1989); in Tanzania among the Hadza (Vincent, 1985); among the Baka of Cameroon and Congo Brazzaville (Dounias, 1996; Sato, this book), and among the Aka in the Central African Republic (Mouton & Sillans, 1954; Bahuchet, 1985). In several societies, harvesting of tubers of wild yams is regulated by religious prohibitions. Such cases are reported in Western Africa (Coursey & Coursey, 1971), among the Kirdi people of the mountains of northern Cameroon (Seignobos, 1992) and in the Andaman Islands (Burkill, 1953; Radcliffe-Brown, 1964; Coursey, 1972).

A related practice is the transplanting of individual wild plants into swiddens or home gardens. Such practice has been described among the Kubu of Sumatra (Sandbukt, 1988), among the Bongo (Chevalier, 1936), and among the sedentarized Aka in the Central African Republic (Guille-Escuret, personal communication), and in various groups along the coast of the Guinea Gulf, notably among the Ibo, Yoruba, Ashanti Ewe and Akan (Coursey, 1976). Chevalier (1936) describes such processes as "protocultivation," meaning that they are performed by "pre"-agriculturalists who are about to adopt full agriculture in a near future. Mouton & Sillans (1954) use the expression "semi-culture" for the same purpose. Braidwood & Reed (1957) propose the neologism "vegecultivation" as a synonym of "specialized foraging" to describe what they consider to be a transitory step between gathering and agriculture.

In previous papers (Dounias, 1993; 1996; 1997) I described a set of manipulations performed on wild yams by the Baka hunter-gatherers of rainforests of southern Cameroon. I suggested that these manipulations have an impact on the geographic distribution and seasonal availability of wild yams. My goal was to criticize any linear and stereotyped view of the evolution of human practices concerning plants. Distinctively of "protocultivation" I argued that such processes do not correspond to an intermediate step leading to full domestication, as implied by the term "protocultivation". I proposed the term "paracultivation" to describe what I consider to be an achieved control of wild resources, which supports the nomadic strategies of hunting and gathering societies. There is no wish nor expressed purpose on the part of the Baka to obtain a complete domestication of these resources.

In the present paper, I first summarize what precisely I mean by "paracultivation" and explore the theoretical issues concerning this concept. I then complete the previous descriptions of the tight socio-cultural relationships between the Baka and wild yams. These geophyte vines are not only food resources: they are also keystone elements of Baka cosmogony. Thirdly, I explain how the achieved knowledge of the Baka about the ecology and biology of wild yams has influenced new paths of research on these starch-rich tuber plants. Finally, I present some of the results I obtained from a quantitative experimental survey, aimed at testing the effect of "paracultivation" on the productivity of starchy tubers.

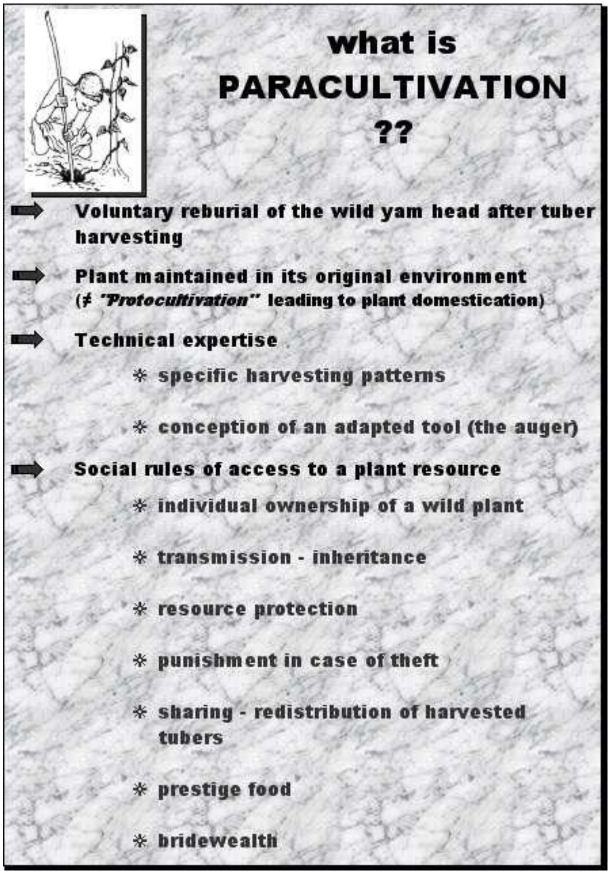

Fig. 1. What is paracultivation.

II. The Concept of Paracultivation

"Paracultivation" defines a combination of technical patterns and social rules which structure the exploitation of wild plants. This term characterizes a particular process of wild plant harvesting which aims at encouraging plant reproduction, so that the plant can be repeatedly exploited. Furthermore, the plant is voluntarily kept within its original environment, in order to better respond to the seasonal mobility of forest dwellers. This maintenance of plants in the forest is the key difference between paracultivation and protocultivation (Fig. 1).

In addition, paracultivation has shaped the technical design of a specific digging tool. Harvesting patterns are specifically adapted to the paracultivated resource. Several social rules may codify access to the resource: exclusive rights of ownership with possible inheritance of managed plants, ritual protection, and the specific treatment the resource receives as food (prestige dishes, components of bridewealth). Although such social treatment of wild resources has been little

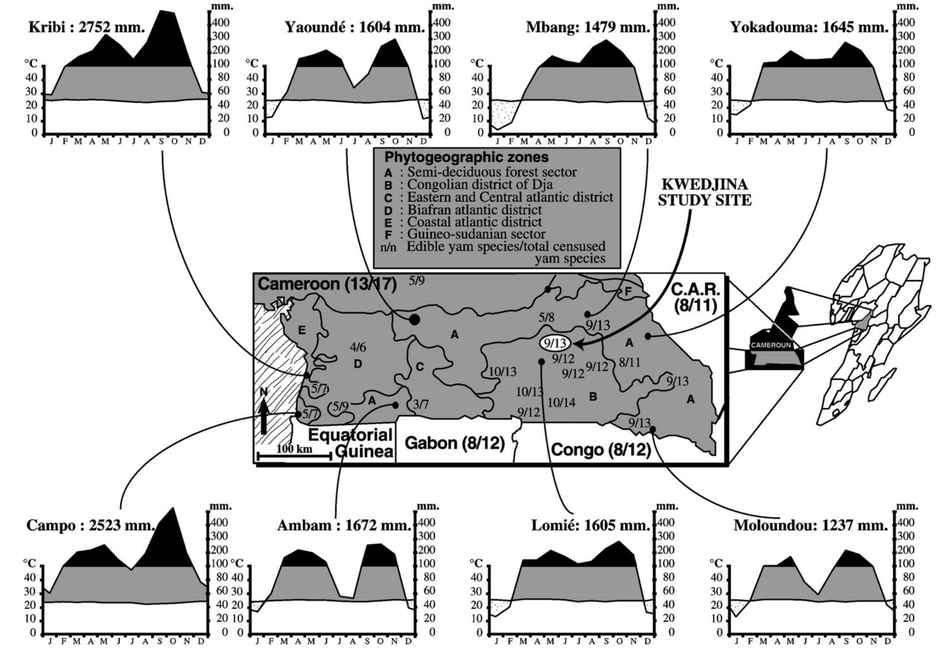

Fig. 2. Study sites on wild yams in Cameroon and their temperature and rainfall profiles.

noted by anthropologists working on so-called "egalitarian" societies, I suspect that "paracultivation" may exist or have existed for a wide range of forest resources. Similar controls of plant reproduction should be systematically investigated, in the perspective of proposing realistic scenarii of the historical ecology of interactive processes between forest peoples and their environment.

THE USE OF WILD YAMS BY THE BAKA PYGMIES

I. Current State of Knowledge

Yams (the pantropical genus *Dioscorea*, of the monocotyledonous family Dioscoreaceae) are vines which store starchy reserves in aerial or underground tubers. Geophytes, such as forest species of Diocorea are very uncommon life forms in tropical forest (Richards 1996). The starchy reserves of yams are a primordial source of carbohydrates for hunter-gatherers. Since 1986 we have conducted systematic censuses of wild yam species in Cameroonian rainforests, estimating densities in different parts of the rainforest zone (Fig. 2). Previous acquired data were published for Central African Republic and Gabon (Hladik et al., 1984). The genus was subsequently partly revised for Congo Brazzaville (Nkounkou et al.,1993) and Western Africa (Hamon et al., 1995). Cameroon is the African country which retains the highest diversity of rainforest wild yam species, with 17 probably species (Hladik & Dounias, 1996) compared to 12 in Gabon (Hladik et al., 1984), 12 in Congo Brazzaville (Nkounkou et al., 1993), 11 in Central African Republic (Bahuchet, 1993b), and 9 in Congo Kinshasa (AFlora databank on web). Among the 17 Cameroonian species, 5 which are strictly limited to forest are still not yet described. Five other species are not specific to rainforest habitats, occurring also in sudanian and sub-sahelian savannas. We exclude here 5 to 6 other wild species which grow specifically in edaphic savannas and associated gallery forests (Nkounkou et al., 1993; Dumont et al., 1994). Of the 17 species censused in rainforests of southern Cameroon, 14 were registered in theBaka area.

II. Yams Are Good to Eat, But also Good to Reflect upon

The relationship between the Baka and yams goes far beyond the simple use as food. I have already described the various non-food uses of wild yams by the Baka (Dounias, 1993; 1996; 1997). Numerous medicinal uses and several prohibitions affecting women suggest close links between yams and fecundity. This continual associations with fecundity should be further investigated with attention to the high concentration of teratogenic substances produced by yams (Neuwinger, 1996). Steroids are known to cause damaging effects during pregnancy (Bongiovanni & McFadden, 1960). Diosgenin - a steroidal sapogenin which is frequently used for synthesis of contraceptive compounds - was isolated from a wide range of wild yam species of different continents (Lewis et al., 1977; Trease & Evans, 1983). Fig. 3 illustrates the fact that *D.mangenotiana* - the queen of wild yams which produces the biggest tuber - plays a key role in the complex interactions between Man, the elephant, and the tutelary spirit "*jengi*". These 3 main inhabitants of the forest share yam tubers as symbolic food (Joiris, 1993; 1998). The elephant is the largest mammal of the rainforests and intervenes as a determinant of hunting powers. The Baka distinguish "ordinary" elephants and "extraordinary" ones, and they have elaborated a whole symbolic system concerning elephants. Similarly, the Baka use two classes of terms to name the queen of yams - one as a food resource, and the other as a ritual object. Several spirits - the tutelary spirit "*jengi*" among them - are closely linked with elephants, and are named "elephant spirits". They play an ambivalent role, as guardians of forest resources and as guiders of hunters to game. Joiris (1998) proposes convincing interpretations of the key symbolic role of elephants and of the "*jengi*" cult (see also Tsuru, 1998).

Some of the complex interactions which intervene in this tryptic centred on *D.mangenotiana* are illustrated in Fig. 4.

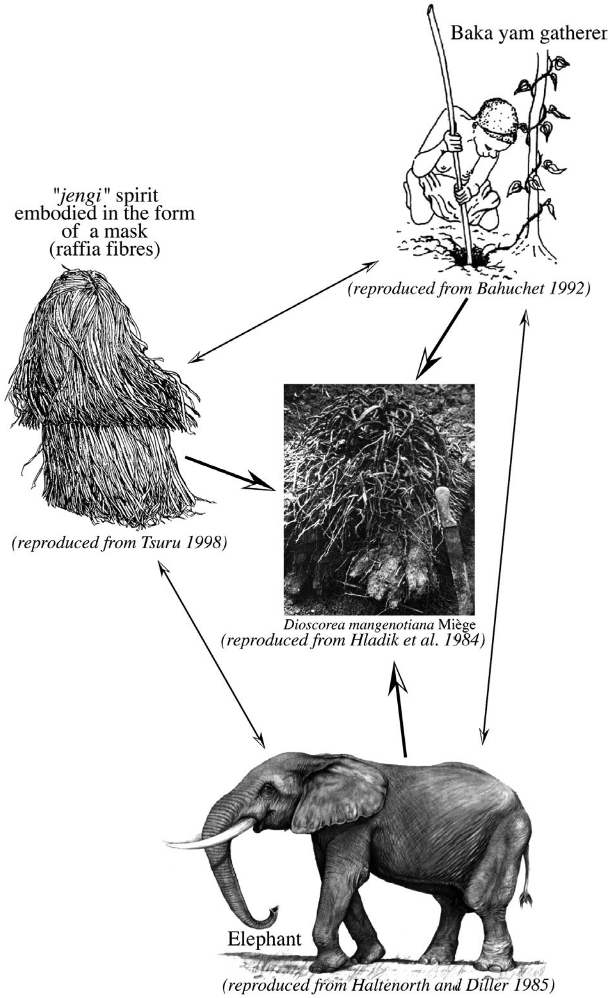

Fig. 3. Consumers of *Dioscorea mangenotiana* Miège: a Baka-Elephant-Forest Spirit triptic.

III. Baka Classification Based on Tuber Morphology

In previous papers (Dounias 1993; 1996; 1997) I also demonstrated that the Baka have detailed knowledge of the ecology and the biology of yams, although these vines are extremely difficult to observe in the forest undergrowth: tubers are generally deeply buried underground, and the sexual parts are hidden high in the canopy. The Baka have also a dynamic understanding of the plant's growth cycle, and are perfectly aware of the double capacity of yams to reproduce sexually as well as vegetatively (Fig. 5). As food resources, wild yams occupy an intermediate position between wild resources (with a dominant sexual reproduction) and crops (most starchy plants grown in forest shifting cultivation are clonally propagated).

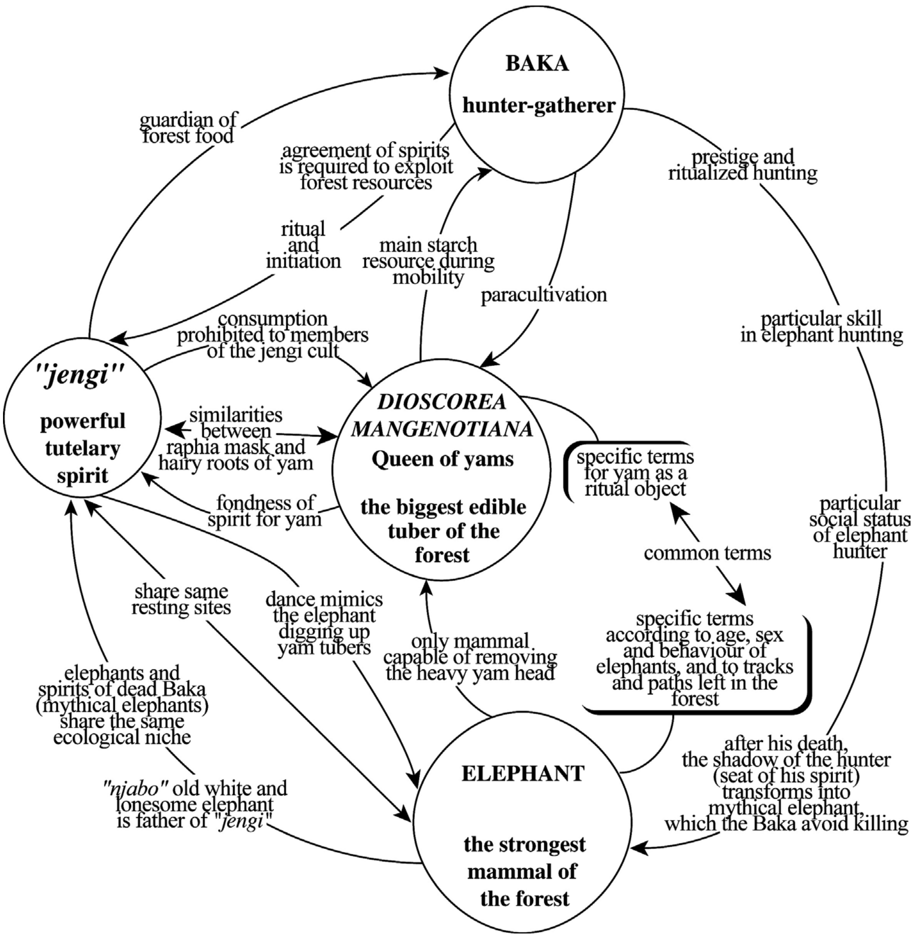

Fig. 4. Interpretation of the tryptic

The Baka accurately distinguish and name the 14 taxa found in their area. They classify distinctively inedible species, which all grow in forest gaps and edges, from edible species, which all persist in closed forest. There is a strong congruence between scientific nomenclature and Baka classification.

Ethnolinguistic data have revealed the unique status of yams in Baka plant nomenclature, because Baka terms applied to yam morphology are drawn from terms refering to human anatomy (Dounias, 1993; 1996). The Baka also have a wide set of terms to name the different kinds and parts of tubers, as well as their consistency and taste (Dounias, submitted). However, Baka classification is predominantly functionnal since it is based on tuber morphology, which is important in defining techniques for extracting tubers (Table 1).

Yam species which form the group "*ndíà*" with inedible tubers all grow in open areas (forest margins, edges) and mostly propagate vegetatively. Starch is stored

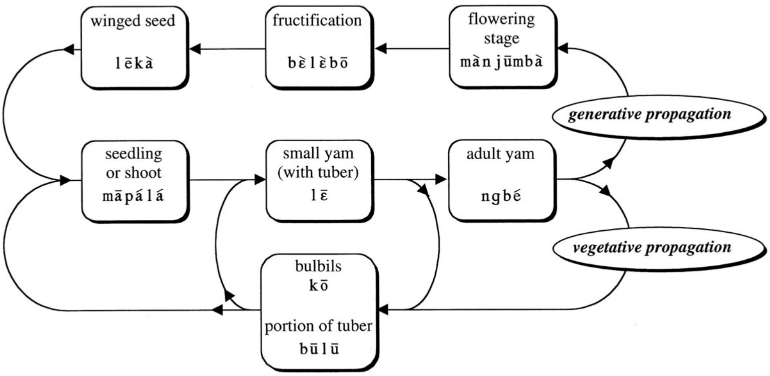

Fig. 5. Wild-yam growth, as understood by the Baka.

Table 1. Ecological and biological characteristics and Baka classification of wild yams.

SCIENTIFIC CLASSIFICATION										BAKA CLASSIFICATION		
Ecological characteristics			Morphological characteristics			Systematic botany: Sub-genus	Section	Species		Baka names	Edibility	Generic terms
open areas	annual or bi-annual stem	annual t.	clockwise turning stems, elongate capsules	both vegetative propagation by bulbils and propagation by seeds	scarcely fleshy tuber (small or branched or fibrous or verticilate)	Helmia	Osophyton	*D. bulbifera*	*	ndià mbòkē	inedible	ndíà
		perennial tuber					Lasiophyton	*D. dumetorum*	*	ndià ɓɛ̀ŋɓɛ̀		
							Macroura	*D. sansibarensis*		ndià pàmɛ̀		
						Eudioscorea	Macrocarpaea	*D. preussii*	*	ɲɛ̄ ndià		
		annual tuber	counter-clowise turning stem				Asterotricha	*D. hirtiflora*	*	ʔè.sɛ̀ngɛ̄	edible	sāpà
closed forest				priority to propagation by seeds	single elongate fleshy tuber			*D. semperflorens*	*	ʔè.sùmà		
							Enantiophyllum	*D. praehensilis*		sāpà		
		perennial tuber			woody head, fibrous swellings with fleshy extremities			*D. mangenotiana*		bā		sub-group ndóndō
	perennial stem		compact capsules					*D. sp. 1*		ɓōlì		
								D. burkilliana		kɛ́kɛ̄		
				principally vegetative propagation by stolons				*D. smilacifolia*		ɓālɔ̀kɔ̀		
								D. sp. 2		njàkàkà		
								D. minutiflora		kūkū		
								D. sp. 3		ʔè.pàngē		

(shaded) Paracultivated yam species
* Rainforest yam species which also grow spontaneously in savannas and associated gallery forests

in aerial tubers (bulbils). Underground tubers are fibrous and are superficially buried. Tubers of *D.preussii* are not toxic, but possess a mechanical defense, in that the tuber is finely digitate, crawling in every direction. *D.bulbifera* has a small underground tuber. Although quite voluminous, tubers of *D.dumetorum* and *D.sansibarensis* are fibrous and highly toxic.

Among the group of edible yam species, the Baka distinguish a sub-group "*ndo-ndo*." The term characterizes round and fleshy reserves stored at the extremities of

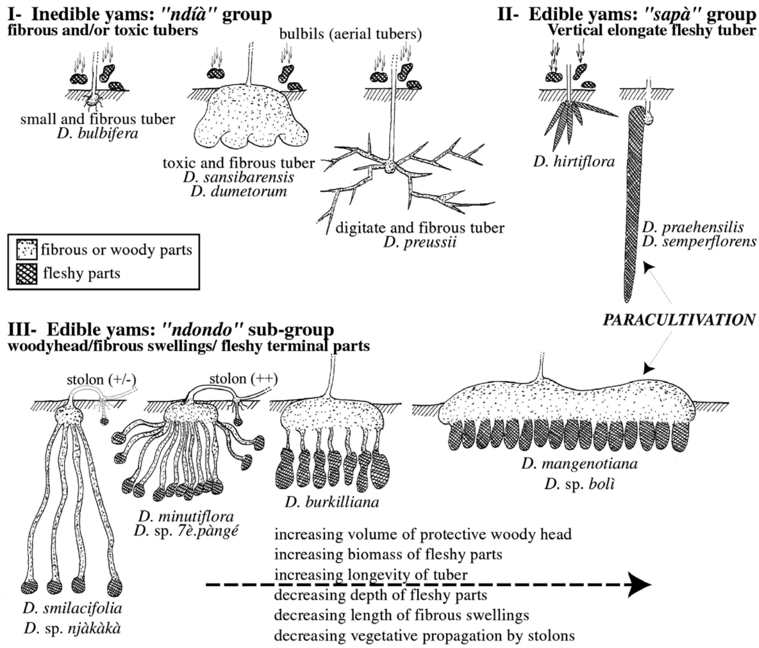

Fig. 6. Tuber morphology.

fibrous swellings. The longer the swellings, the smaller the fleshy reserves and the woody head, and the deeper the starch is buried (*D.smilacifolia*, *D.*sp. *njàkàkà*). At the other extremity of this sub-group, *D.mangenotiana* has a different tuber morphology. The tuber is superficially buried, fibrous swellings are absent, and the spherical fleshy reserves protected beneath the large woody platform-like head are numerous and large (Fig. 6). This permanent heavy large and woody head is established when *D.mangenotiana* has reached the adult stage. It efficiently recovers fleshy reserves against predators (except man and the elephant).

D.semperflorens and *D.praehensilis* bear annual stems and produce annually renewed tubers that are elongate and vertical. Tubers of these species lack protection in the form of a superficially buried woody platform, but this is compensated by the depth of burial of tubers and by their annual renewal. During the formation of the new tuber, the plant may employ chemical defenses, because the young tuber is highly bitter. Only 3 among the 14 yam species are concerned by paracultivation: *D.semperflorens*, *D.praehensilis* and *D.mangenotiana*. In view of Baka classification based on tuber morphology, paracultivation concerns species which produce the largest starchy biomass, independently of plant cycle and propagation strategy. Such significant differences of plant morphology and ecology among paracultivated species have led to two distinct patterns of harvesting.

Characteristics of yam tubers have been the object of little attention by taxonomists. However, a reconsideration of yam classification including traits such as tuber morphology, propagation mechanisms (alternative strategies by bulbils

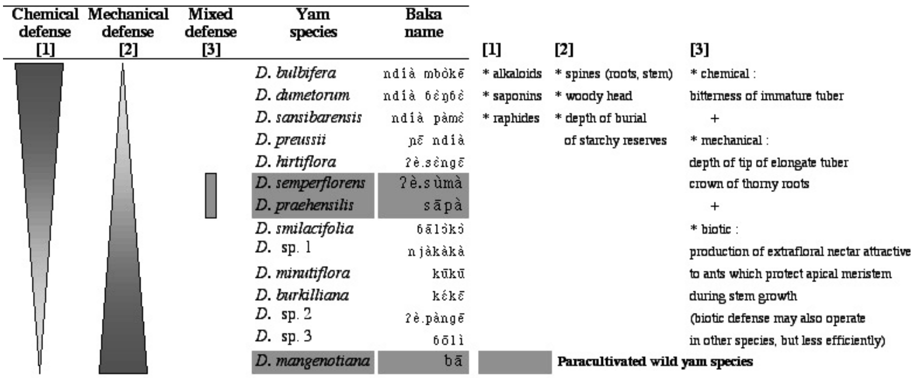

Fig. 7. Protection strategies.

and stolons), and strategies of protection, opens up promising perspectives concerning the morphological and ecological diversity of tuber bearing plants, and the functional role of these underground reserves in their biology (McKey et al., 1998) (Fig. 7).

IV. Pattern of Harvesting

The Baka have implemented a specific technical process for harvesting the vertical elongate tubers of paracultivated *D.praehensilis* and *D.semperflorens*. Earth bordering the tuber, and starchy parts of the tuber freed by excavation, are removed using a special tool, a sort of auger which enables them to excavate a cylinder of earth. The hole is excavated in such a way that the head of the tuber is not affected. The gatherer takes care to preserve a portion of starch with the head, and to leave the terminal part of the tuber. The pit is backfilled with a mixture of earth and humus. The backfill is enriched with organic matter and is less compacted than the original soil, so that the renewed tuber encounters less mechanical resistance during its growth and development. Furthermore, a second stem resprouts from the tip of the tuber, which is voluntarily not completely extracted, and a second tuber develops from this part. Consequently, paracultivation duplicates tubers within each yam pit (Dounias, 1993; 1996).

The auger used by Baka and Aka Pygmies specifically for the harvesting of these paracultivated yam species is of similar design in the two groups, but there are distinctive differences. The type of wood used to manufacture augers is different between Aka and Baka. The weight of the auger differs in consequence, as well as how it is manipulated. Such subtle differences reveal two parallel technical evolutions (Dounias, submitted). Each population has adapted the tool in order to respond to the distinct physiological characteristics and habitat preference of the dominant harvested species. The Baka auger is suitable mainly for *D.praehensilis* tubers (the dominant species within Baka country). The tuber of *D.praehensilis* is large, firm and develops in heavy clay-rich soils. The Aka auger is better adapted

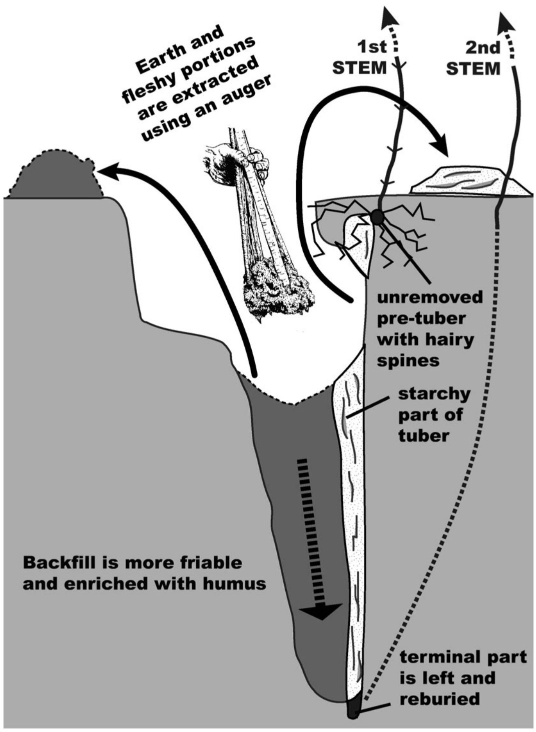

Fig. 8. Harvesting of *D.praehensilis* tuber

to excavation of *D.semperflorens* tubers (*D.praehensilis* is rare in Central African Republic). The tuber of *D.semperflorens* is thinner, more watery and fragile, and grows in light and friable soils.

Harvesting of tubers of *D.mangenotiana* tuber proceeds differently. The Baka use a wooden stake as a lever to uproot the heavy and large woody head. Once the fleshy parts have been harvested, the tuber is set back in its original position. Frequently, a colony of aggressive ants will opportunistically nest in the cavity thus formed beneath the woody head, discouraging mammalian predators of tubers. For all paracultivated species, I noticed that repeated harvesting induces the production by the plant of a crown of adventitious thorny roots covering the top of the head (see photo of Fig. 3). This crown of roots is totally absent on yams that have not yet been harvested, and seems to have two functions: stabilization of the head in less compacted soils (due to repeated harvesting), and mechanical protection of tuber head against herbivores. Paracultivation thus seems to provoke production of a supplementary mechanical protection by the plant, and has the effect of reducing competition with humans from other tuber consumers such as bushpigs and rodents (Fig. 8).

EFFECTS OF PARACULTIVATION ON PLANTS

I. Effects on Demography

From 1993 to 1998, using Baka expertise on yams as a starting point, I carried out a quantitative field study of how paracultivation may affect wild yam populations and tuber production. I established an experimental plot in an area extremely rich in *D.praehensilis*, located near Kwedjina village (3°54′ N/13°45′ E, see Fig. 2) in the Eastern province of Cameroon. The study site receives an average of 1,650 mm. rainfall annually. The dry season lasts from November to February. Vegetation is semi-deciduous forest, dominated by Ulmaceae and Sterculiaceae (Letouzey, 1985). In this region, the Baka have close relationships with Mezime villagers who are Bantu agriculturalists.

The study plot was a 1,200 m^2 rectangle, divided into 10×10 m. quadrats (total: 120 quadrats). The plot was set up in a 25 to 30 year-old secondary regrowth. Through negotiation with villagers, the plot was free of any attempt at cultivation during the study period. Within the plot, each individual plant of yam and yam-like (*Dioscoreophyllum cumminsii*, Menispermaceae) species were censused and mapped, including all stages from seedling to adult. Among other observations, I noted whether tubers had been already harvested and by whom (Baka foragers or Mezime villagers). The Mezime villagers occasionally dig up *D.praehensilis* tubers, but they do not use the auger. Harvesting by the villagers is thus superficial and the tuber head is never reburied, frequently leading to death of the plant.

Experiments were focused on *D.praehensilis*, which was dominant (57% of individuals of yam and yam-like species censused, see Fig. 9.) I divided the plot into 7 sub-plots. Six of these formed production blocks, which were harvested successively at contrasted seasons. Each production block comprised 100 to 120 m^2. Production blocks appear in grey in Fig. 9. The last sub-plot (white quadrats on Fig. 9, comprising 520 m^2) was preserved for further experiments (physiological development and defense of young stems against insect herbivores by ants) and for comparative measurements on unharvested individual plants.

The density of yam plants observed in the Kwedjina "grove" is extraordinarily higher than the densities obtained in transects in other sites in Central African forests (Table 2).

In each quadrat, yam inidviduals were marked, mapped, identified, measured (stem length and diameter) and described (for example age class, presence of leaves, flowers or fruits, traumatisms of any kind, density and size of spines on stem, etc). The light environment of each harvested individual plant was also measured using a fish-eye lens. During each harvesting session, Baka harvesters were told to respect paracultivation practices. The age and gender of each harvester was noticed, and the time allocated to harvesting of each plant was calculated, including resting time. The time for manufacturing the auger was also estimated, and I noticed the kind of wood employed, as well as the distance covered to find the small tree for making it. Finally, each harvested tuber was measured (length, diameter), weighed, and described (color, state of starch, production of diverticules, spiny roots, attacks by beetle larvae and adults, etc.).

A total of seven harvesting sessions where organized: 5 times at three month intervals from September 1993 to September 1994, again in April 1996 and finally in April 1998. This represents over 560 harvested yam plants (Fig. 10).

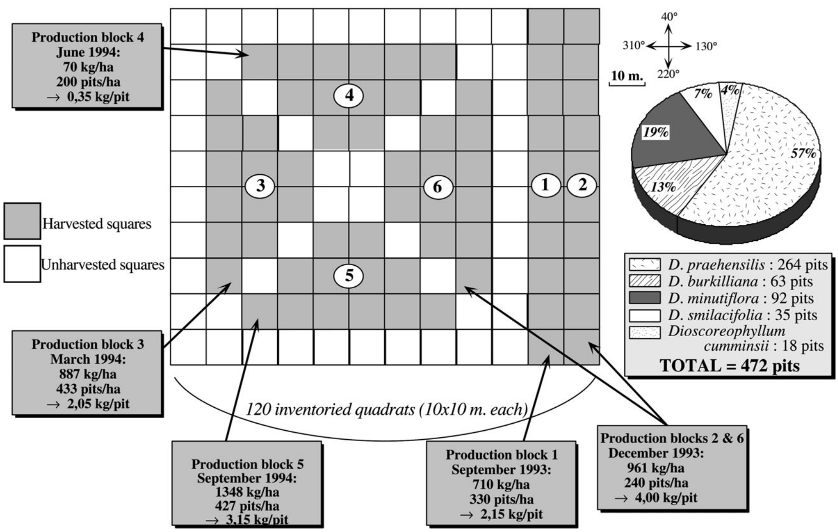

Fig. 9. Kwedjina study plot.

Table 2. Wild yam densities obtained in Central African forests.

	Country		Type of forest	Inventoried surface (m^2)	nb transects	Density (stem/hr)
Primary forest	Cameroun	(**)	coastal evergreen	28,000	9	40
	Cameroun	(**)	continental semi-deciduous	20,000	5	53
	CAR	(*)	continental semi-deciduous	20,200	7	45
Secondary forest	Gabon	(*)	anthropogenic edge	400	1	175
	Cameroun	(**)	post-agricultural regrowth	800	2	160
	Cameroun		Kwedjina yam plot	12,000	-	393

(*) from Hladik et al., 1984; (**) from Hladik and Dounias 1996

II. Tuber Production and Seasonal Variation

As revealed by Fig. 9, production of edible starch in *D.praehensilis* tubers varied significantly over the year. Production in December (4,000 g/pit) was 11 times

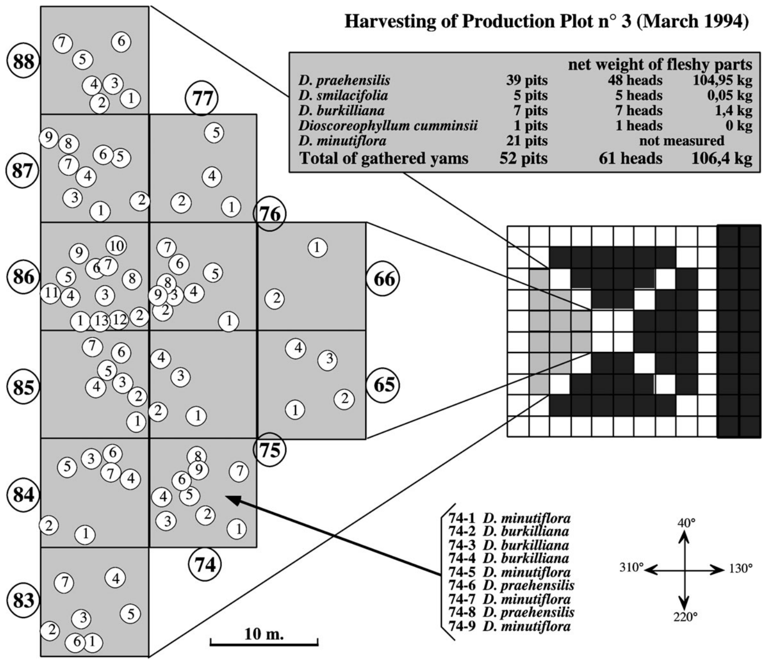

Fig. 10. Example of harvesting session.

higher than production in June (315 g/pit). Furthermore, the gustatory quality of the tuber differs. During the rainy season tuber is described as "*salè*" (aqueous and fibrous) and is only sucked as emergency food. During the dry season, tuber is qualified as "*fumbo*" (firm and tender) and is much appreciated.

D.semperflorens - the other paracultivated yam species producing annual elongate vertical tubers - was totally absent in Kwedjina. In March 1995, I observed a gathering session of *D.semperflorens* pits which had never been harvested before (near Bizam village, 2°57′ N/14°19′ E). The quantity of starch gathered was about 280 g/pit. Starch biomass per individual plant was ten times lower than for *D.praehensilis* at the same season. However, the time necessary for harvesting *D.semperflorens* was lower. Seven women harvested 40 yam pits in 5 hours 30 min, including the time spent in searching plants, making augers, reburying tuber heads, and resting. Following my calculation of time allocation, the same group of gatherers would have harvested 16 *D.praehensilis* in the same period of time, representing nearly 33 kg. It may be concluded that the yield of *D.praehensilis* gathering is 3 times higher than the yield of *D.semperflorens.*

Sato (this volume) gives data on wild yam harvesting in Northern Congo Brazzaville. His measurements were conducted during the rainy season and mainly concern species with perennial tubers which belong to the "*ndondo*" sub-group. His estimations of starch production are consistent with those we have published earlier: 1 to 3 kg of fleshy tubers per hectare (Hladik & Dounias, 1993; 1995; 1996). This season, in which few starch reserves have accumulated in the annual tubers of

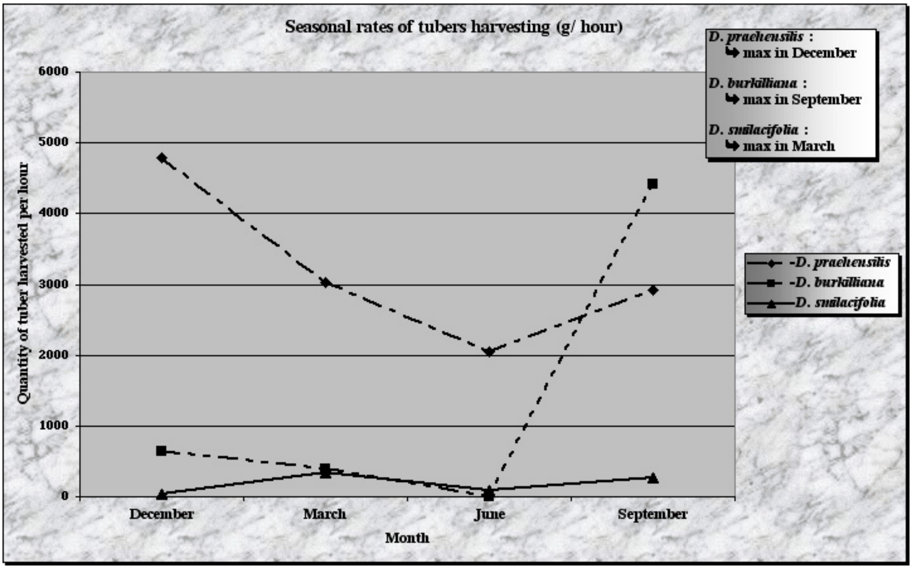

Fig. 11. Seasonal production of tubers.

D.praehensilis, is more convenient for harvesting "*ndondo*" species. Highest yield for *D.praehensilis* is in December, versus March for *D.smilacifolia*, and September for *D.burkilliana* (Fig. 11). Sato's estimations for *D.minutiflora* and the yam-like *Dioscoreophyllum cumminsii* are based on measurements conducted in August. Starch production is proportionally 6 to 33 times higher for annual and paracultivated species than for species of the "*ndondo*" sub-group, if we compare yields obtained during the periods of maximum production of each species. Nevertheless we lack estimations for *D.mangenotiana*.

There is a seasonal complementarity of tuber maturation between species with perennial tubers and those with annual tuber, thus enabling continuous procurement of wild starch-rich food for forest dwellers throughout the year. However, the dependance on wild source of starch changes with season and is function of hunter-gatherers activities and task groups. The period for gathering paracultivated *D.semperflorens* and *D.praehensilis* (Fig. 12) coincides with intensive hunting and gathering activities from forest camps, where families merge into large-size bands. This period is convenient for honey gathering, and for hunting conducted with crossbows and spears. Among the Aka (Central African Republic) and the Mbuti (Congo Kinshasa), it is also the most suitable period for collective hunting conducted in large groups using nets (Bahuchet, 1992). The availability of yam tubers during this period is crucial. In contrast, during the period of production of "*ndondo*" yams, men and women form separated task groups. Men leave the village for expeditions centred on hunting with spears and honey harvesting, while women are occasionally occupied by dam fishing. During the short dry season, small nuclear families disperse in the forest for the gathering of *Irvingia gabonensis* kernels, and the oil-rich seeds of *Baillonella toxisperma*, and later on for

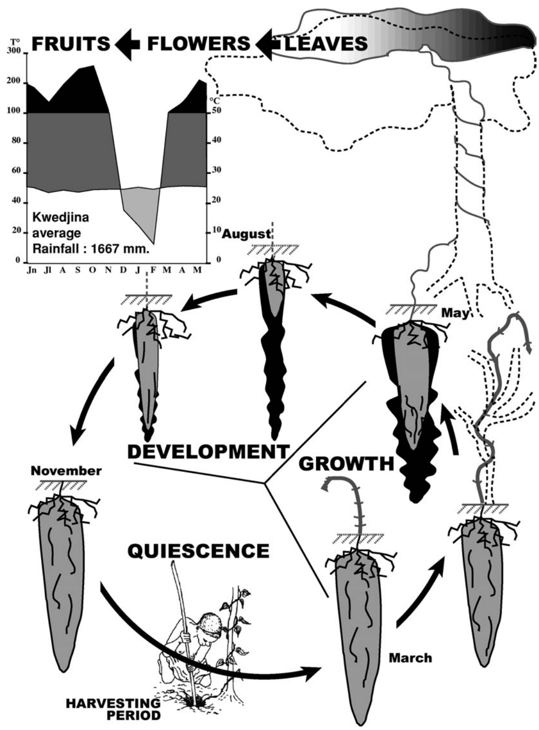

Fig. 12. Biological cycle of *D.praehensilis* (adapted from McKey et al. 1998).

caterpillars. Expeditions in the forest are of short duration, and contacts are permanently maintained with the village, where forest products are exchanged for starchy crops.

III. Biological Cycle of *D.praehensilis*

This extensive survey in Southern Cameroon allows a synthetic reconstruction of the whole biological cycle of *D.praehensilis* (Fig. 12), which highlights the causes of seasonal variation of tubers in size and quality. I consider the beginning of the rainy season as a starting point, when the plant, which has stored its maximum quantity of underground reserves before the beginning of the preceding dry season, must renew its aerial stem.

As monocotyledonous vines, yams lack a cambial meristem, therefore their stems are unlikely to be capable of secondary growth. It is crucial that the apical meristem of the new stem shoot reach the canopy without being damaged by herbivorous insects. The aphyllous stage of stem growth is the critical step of the plant cycle. If the stem fails to reach the canopy, the yam plant will not be able to reproduce, since there will be no photosynthesis enabling the renewal of tuber reserves, and no sexual reproduction ensuring further plant generation. Yam species which produce annual stems and tubers have elaborated a biotic defense against herbivores. From glands located near the apical meristem, they produce a rich nectar which attracts ants. These ants protect the stem apex from phytophagous insects (Di Giusto et al., submitted).

During growth of the stem, the plant needs not only energetic reserves but also costly nutrients which are necessary for the building up of the stem which progressively becomes more lignified. Tubers of yams are thus also rich in minerals and protein (more than 10% of dry weight for some species, Hladik and Hladik et al., 1984; McKey et al., 1998). The critical phase of stem growth intervenes between March and May. Once it has reached the canopy, the stem branches and bears leaves.

Tuber reserves are mobilised to sustain growth to the canopy and decrease until the photosynthetic surface is fully established (June-July). From this point, photosynthesis will now provide energy for the renewal of tuber reserves. During the first steps of its development, the tuber is fragile, superficially buried and extremely bitter, suggesting that the plant has temporarily adopted chemical protection against predators. At the same time the plant becomes sexually active. In November, once reserves have been restored by the new tuber, the stem and leaves desiccate, and winged seeds are released from dehiscent and mature capsules and dispersed by wind. Tuber reserves are maximum during the entire dry season, until the arrival of the next rainy season, announcing the production of a new stem.

November to March is the best period for harvesting *D.praehensilis* and *D. semperflorens* tubers. Tuber harvesting from June to August has no particular effect on the plant, but the tuber is emptied, nutritionally poor and almost inedible. In contrast, any harvesting during March-May (stem growth) and September-October (renewal of tuber) affects seriously the survivol of the plant; although edible, tubers harvested at this time are not suitable nor tasty for consumption.

IV. Tuber Reproduction after Paracultivation

The effect of paracultivation on tuber production is shown in Fig. 13. I compare the average yield of *D.praehensilis* tuber harvesting per hour and per gatherer, according to the number of stems emerging from each yam pit. For any period of harvesting that we may consider, the yield was significantly higher in paracultivated pits ("*ndíà*," characterized by 2 stems per pit), than the yield of individuals which were harvested for the first time ("*mòpima*," characterized by only one stem per pit). The situation is more complex for pits which contain 3 stems or more, since the yield decreases when the number of stems exceeds 4 per pit. These kinds of yam pits are called "*moyaki*" by the Baka. This term means that the yam had already been harvested, but had not been reburied. They generally correspond to yam individuals which were harvested only superficially by the Mezime villagers. Because the villagers do not use the auger, much starch is wasted during harvesting. Even though the production of such pits is non-negligible, the Baka are reluctant to dig them up: it is hard work and the use of the auger is no longer efficient.

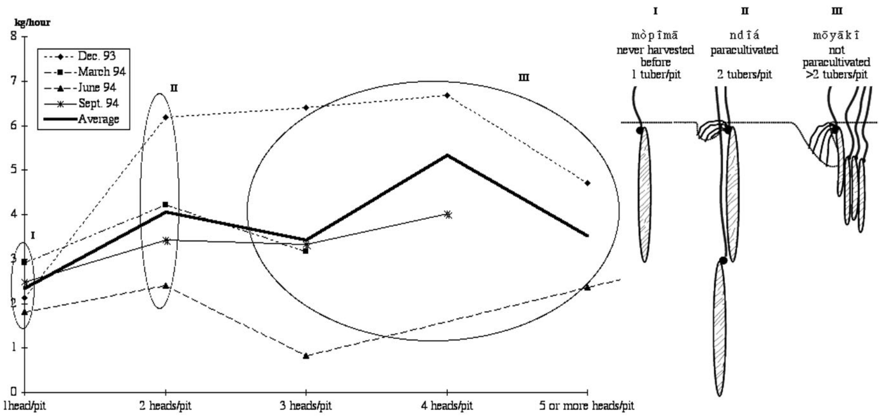

Fig. 13. Effect of paracultivation on tuber production.

Furthermore, figure 13 takes into account only harvestable individuals. I must emphasize that mortality among "*moyaki*" yams was very high. Paracultivation requires that a reasonable portion of starch is left with the head (see Fig. 8). When yams are harvested without the intention of paracultivation (such as harvesting performed by Mezime farmers), no starch is left with the tuber head. The head is not reburied and is consequently exposed to decay, desiccation and predators. In contrast, in December 94, I recensused all the individuals (n=25) which had been harvested and reburied for the first time during the December 1993 harvesting session, respecting paracultivation practices. None of them had died.

However, harvesting on 5 samples of these individuals revealed that the average biomass of starchy parts was 20% lower than one year before. Reduced production one year after reburial may be explained by the energetic investment of yams for the implementation of a protective crown of thorny roots. The Baka are aware of the reduction in yield occasioned by too frequent harvesting, and affirm that reharvesting of paracultivated plants should intervene only after two or three years.

CONCLUSION

Only a small part of our results are presented here. Results dealing in detail with the effects of paracultivation on yam population biology are in preparation and will be submitted to scientific journals specialized in ecology and anthropology. We are now working on elaborating a matrix model that would integrate the whole set of data we have been gathering during 4 years in the study plot. This model would include data on seedling survivorship, which appears to be conditioned by light environment (Elias, 1996). This model should enable a test of the hypothesis that - in accordance with Baka affirmations - paracultivation has a positive effect on wild yam demography, without affecting tuber production when it is practices at appropriate intervals. This work, based on Baka knowledge and practices, has also guided the design of further investigations into yam biology, notably on the biotic anti-herbivore defense by ants and the possible physiological role of nectar production during the aphyllous stage of stem growth. The efficiency of the protective mutualism between yams and ants is being tested by B. Di Giusto during his Ph.D research, on the individual plants which were maintained within unharvested quadrats of the Kwedjina study plot. The biological cycles of yam species with perennial stems and tubers which form the "*ndondo*" sub-group are still not well understood, and necessitate longer term observations.

Human activities undoubtedly influence the forest environment. However, complex interactions between plants, animals and humans are not only restricted to agriculturalists. Through the ages, forest dwellers of Amazonia (Balee, 1989), South-East Asia (Rambo, 1979; Hutterer, 1982) and Central Africa (Laden, 1992; Ichikawa, 1999) have certainly affected and even managed the spatial as well as temporal distribution of resources in the forests. Full domestication was certainly not the final goal of these attempts at resource control. Paracultivation - not only for yams but probably for a wide set of resources - encourages us to reconsider some preconcieved stereotypes about foraging peoples, who are generally seen as opportunists and parasites of their environment. Further understanding of such types of indigenous resource management is necessary for estimating the role of man in the dynamics of tropical rain forests in the past, and should be of great interest in planning the more effective involvement of foraging peoples in the sustainable management of the rain forests.

However, ecological perspectives should not be separated from cultural aspects of resource perception. Wild yam gathering forms a complete cultural complex among the Baka, as do honey harvesting and elephant hunting (Bahuchet, 1993a). If *D.mangenotiana* happens to lose its symbolic function as food shared by the Baka, elephants and forest spirits, there will be no coherent cultural framework for incorporating "paracultivation" into a realistic way of managing forest resources by the Baka.

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