African rice (*Oryza glaberrima*): History and future potential

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Contributed by Olga F. Linares, October 4, 2002

The African species of rice (*Oryza glaberrima*) was cultivated long before Europeans arrived in the continent. At present, *O. glaberrima* is being replaced by the introduced Asian species of rice, *Oryza sativa*. Some West African farmers, including the Jola of southern Senegal, still grow African rice for use in ritual contexts. The two species of rice have recently been crossed, producing a promising hybrid.

There are only two species of cultivated rice in the world: *Oryza glaberrima*, or African rice, and *Oryza sativa*, or Asian rice. Native to sub-Saharan Africa, *O. glaberrima* is thought to have been domesticated from the wild ancestor *Oryza barthii* (formerly known as *Oryza brevilugata*) by peoples living in the floodplains at the bend of the Niger River some 2,000–3,000 years ago (1, 2). The two strains of *O. sativa* (*Oryza japonica* and *Oryza indica*) were domesticated independently, both probably in China (3, 4). It is also possible that Asian rice was domesticated in tropical Asia south of China, but evidence for this possibility is still lacking.

At the present time, *O. glaberrima* is being replaced everywhere in West Africa by the Asian species, introduced into the continent by the Portuguese as early as the middle of the 16th century (1). The native species is thus rapidly diminishing in importance. As a National Research Council report points out, "this should not be allowed to happen. The rice of Africa (*O. glaberrima*) has a long and noteworthy history" (5). This article begins with information about the past and present status of African rice and then moves to a detailed example of when, how, and why it was cultivated by the Jola, a population of ancient rice growing peoples living in the swampy coastal areas of Casamance, in southern Senegal. It compares the status of *O. glaberrima* in 1960 with what it is today, when only remnant populations remain. My purpose is to explore the reasons for the demise of the species and document the contexts in which it still survives. The final section argues that farmers need to preserve African rice and improve its cultivation. In a continent where food deficits are the rule, this hardy species has qualities that make it superior to Asian rice as a subsistence crop. Recent agronomic advances now allow for gene transfer between the two species, thus creating hybrids that are better adapted, and higher yielding under adverse conditions, than either parent species.

Ancient History of the *O. glaberrima* Species

In the absence of firm archaeological evidence it is difficult to assess whether Portères (1, 2) is correct in suggesting that *O. glaberrima* was first domesticated in the Inland Delta of the Upper Niger River, in what is today Mali, ≈2,000 or 3,000 years ago. According to Portères, the species spread to two secondary centers of diversification, one in the coast of Gambia, Casamance, and Guinea Bissau, the other in the Guinea forest between Sierra Leone and the western Ivory Coast.

Harlan *et al.* (6) have suggested an alternative theory. They have proposed that *O. glaberrima* was selected for at several different localities within the vast forest and savanna areas, where the wild ancestor species *O. barthii* grew and was harvested by ancient hunting–gathering human populations. Whether one or several centers of African rice domestication existed, the fact remains that African rice was first cultivated many centuries before the first Europeans arrived on the West African coast.

The early Colonial history of *O. glaberrima* begins when the first Portuguese reached the West African coast and witnessed the cultivation of rice in the floodplains and marshes of the Upper Guinea Coast. In their accounts, spanning the second half of the 15th century and all of the 16th century, they mentioned the vast fields planted in rice by the local inhabitants and emphasized the important role this cereal played in the native diet. The first Portuguese chronicler to mention rice growing in the Upper Guinea Coast was Gomes Eanes de Azurara in 1446. He described a voyage along the coast 60 leagues south of Cape Vert, where a handful of men, navigating down a river that was probably the Gambia, went ashore: "they said they found the country covered by vast crops, with many cotton trees and large fields planted in rice . . . the country looked to them as having the aspect of a pond (i.e., a *marais*)" (7). A few years later, in 1455, Alvise da Cadamosto confirmed the previous observations by mentioning the many varieties of rice that were grown in the Gambian area (8). That rice growth was not confined to the valley of the Gambia River, but was practiced by many populations living along the West African coast known as the Southern Rivers, was brought out by Eustache de la Fosse in 1479–1480. Talking about a visit he made to the Île de Los, off the coast of Conakry, the capital of present-day Guinea, he mentions that at the entrance of the market "there were several large mounds of rice, and with human labor it was carried back to the ships" (9). Scattered references to rice are also found in the chronicle of Duarte Pacheco Pereira dating from 1506–1508. Besides mentioning that the Falupos, a general term used at the time for the Jola living in the area between the Casamance and Guinea Bissau, had lots of rice, he alluded to the Cocalis (the present-day Landuma) and the Biafadas, both of whom still grow rice in the coastal areas of Guine Bissau and Guinea Conakry (10). Also, the well-known compiler, Valentim Fernandes, whose second-hand account dates from about the same time (1506–1510), remarks that "this land is rich in food, to wit rice, millet and beans, cows and goats, chickens and capons and numerous wines and other food products" (11).

The first Portuguese observers greatly admired the native rice-growing technology, because it involved diking, transplanting, and other "intensive" practices. Already in the 1590s, André Alvares d'Almada, who was born in Cabo Verde of mixed European and African heritage (thus a Luso-African) and was well seasoned by travels up and down the Guinea Coast that helped him to become a good naturalist, provides us with an account of rice cultivation as practiced by peoples living along the Gambia, Casamance, and Geba rivers. He wrote that "in these parts the rainy season starts at the end of April, beginning of May. The Blacks make their rice fields in these plains; they construct dikes of earth for fear of the tides, but despite them [the dikes] the river breaks them frequently, flooding the rice fields. Once the rice has sprouted, they pull it out and transplant

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 www.pnas.org/cgi/doi/10.1073/pnas.252604599

it on land that is less inundated, where the rice yields" (12). Although d'Almada seems confused about the practice of transplanting, which is done in deep water rather than well-drained land, he provides ample evidence that the natives of those areas were growing swamp or wet rice in diked fields using intensive techniques.

Nearly a century was to pass before we have another detailed account of local rice-growing practices. In 1685 or thereabouts, Sieur de la Courbe crossed the hinterland between the Gambia and Guinea Bissau, a territory that he mentions was occupied by the Felupos (the Jola) and the Banyun (the ancient Bainouk). At one point he went out for a walk along what may have been a tributary of the Soungrougrou *marigot* (or tidal creek) dividing Lower from Middle Casamance (13). He writes, "I saw fields of rice located along the river; they are traversed by small walkways from space to space that prevents the water from running out; after it rains, one seeds the rice, which grows in the water" (14). In another part of de la Courbe's account, the section that Labat plagiarized in 1728 and ascribed to a governor called André Brue, he gives a description of the countryside: "the low lands, and those that are watered by ordinary spillover from the heavy rains at the height of the season, or inundated by springs or currents coming from higher up, are all planted in rice. They [meaning the people] cut up their land by means of small dikes that retain water so that the rice is always bathed; because it likes to be in the water; and it grows as the water rises" (15). Further on he describes the technology used by the Felupos or Jola: "The lands that are flat and well irrigated are perfectly cultivated, and they do not use but shovels of wood provided with a flat piece of iron at one end and a long handle to cultivate" (ref. 15, pp. 43–44). This is one of the most detailed early references (circa 1685) to the *kajandu*, the long-handled fulcrum shovel used by the Jola and their close relatives in Guinea Bissau to turn over the earth and prepare their fields.

To summarize, the Jola and their neighbors were certainly growing wet rice and using intensive techniques, such as diking to retain rainwater and transplanting, at the time they first encountered the Europeans. The rice they grew was doubtless the African species *O. glaberrima*. Although it is not known with certainty when and where the first varieties of Asian rice *O. sativa* were first introduced into West Africa, the general consensus is that, beginning in the 16th century, the species spread and was adopted by peoples living in the Upper Guinea Coast who had previous experience growing the local African species.

Differences Between *O. glaberrima* and *O. sativa* and Their Distribution

Slight morphological differences separate the two species of rice, making them difficult to tell apart in the field. Generally speaking, African rice has small grains that are pear-shaped and have a red bran and an olive-to-black seedcoat, straight panicles that are simply branched, and short, rounded ligules. However, some Asian rice types also have pear-shaped grains with a red bran, and some African types have pointed ligules (6). Other ecological characteristics of the two species may more important from the point of view of human selection potential. African *O. glaberrima* varieties have certain negative features with respect to the Asian O. *sativa*: the seed scatters easily, the grain is brittle and difficult to mill, and, most importantly, the yields are lower. But the *O. glaberrima* types also offer distinct advantages: the plants have luxurious wide leaves that shade out weeds and the species is more resistant than its Asian cousin to diseases and pests. Moreover, African rice is better at tolerating fluctuations in water depth, iron toxicity, infertile soils, severe climates, and human neglect. Some *O. glaberrima* types also mature faster than Asian types, making them important as emergency food (5). These characteristics have made it worthwhile to attempt to cross both species, a feat that that has recently met with considerable success.

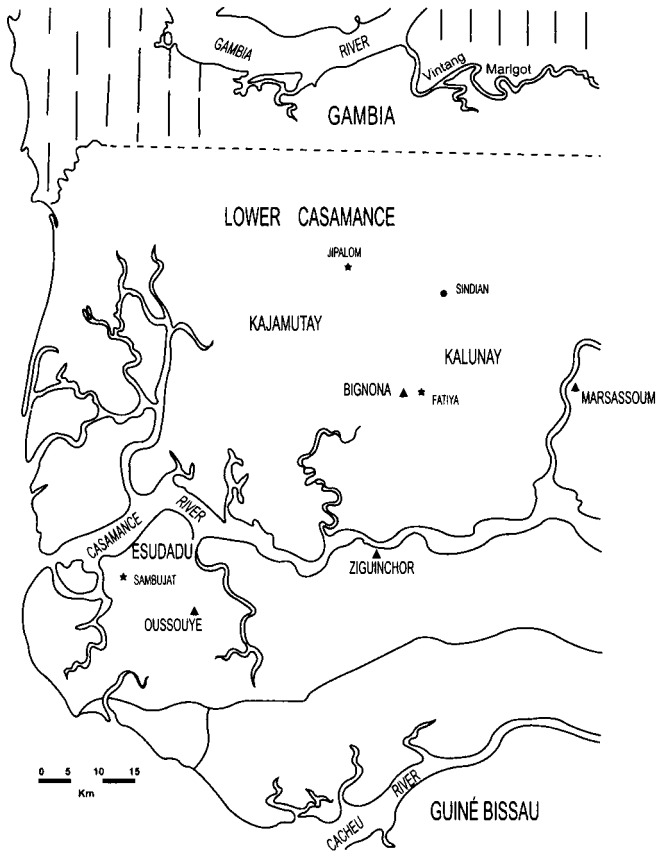

Fig.1. Map of Lower Casamance, Senegal.

In West Africa, rice is grown as the main staple crop by 10–15 million people living in societies that are distributed along the coast, from the Casamance in Senegal to the bend of the Bandama River in the Ivory Coast. In addition, rice is an important but not a dominant crop in the drier savanna zones from the Senegal River to Lake Chad. Rice is also grown today as a commercial crop in Ghana and Nigeria (6). In the coastal area, where rice is a dominant subsistence crop, isolated pockets of *O. glaberrima* cultivation remain in Guinea Bissau, Guinea, Sierra Leone, and in the Casamance region of southern Senegal, the zone we are concerned with here. Everywhere, however, *O. glaberrima* types are fast being replaced by the higher yielding *O. sativa* varieties. This phenomenon is documented below with respect to the Jola peoples of Casamance, who some decades ago planted numerous varieties of African rice but no longer do so. The discussion that follows documents the *O. glaberrima* types that Jola cultivated in the 1960s, the reasons why they were abandoned, and the cultural context in which they still survive.

The Jola Cultivated Numerous *O. glaberrima* Varieties in the 1960s

The Jola people, who number more than 300,000, live in the Lower Casamance, a region located in the southwest corner of Senegal (Fig. 1) that has a sub-Guinean tropical climate and a marshy, coastal landscape. Numerous creeks or *marigots*, filled with brackish water and lined with mangrove vegetation, branch out from the Casamance River, crisscrossing the low-lying areas and creating an amphibian landscape. Lower Casamance is one of the two centers of *O. glaberrima* diversification suggested by Portères (1, 2).

Fig. 2. Men prepare the rice fields using the *kajandu*.

The Jola practice a labor-intensive form of wet-rice cultivation. They till the soil, and dike and bund the paddy fields using a unique fulcrum shovel known as the *kajandu* (Fig. 2). The Jola use sophisticated methods of rainwater control and distribution, keep the tidal waters out of their rice fields and construct fish ponds, apply abundant amounts of cattle dung for fertilizer, transplant seedlings from prepared nurseries into flooded fields (Fig. 3), weed the crop, and harvest the rice panicles individually (16) (Fig. 4). Important regional differences exist in the gender division of labor, the dominance of upland versus floodplain cultivation, the ratio of transplanted to direct-seeded rice, and the role played by secondary and commercial crops. But everywhere in the Jola area, rice is the dominant subsistence crop. It is grown all over the countryside, in tidal zones recovered from the mangrove vegetation, inland freshwater valleys, and low plateaus. It is also cultivated in peri-urban zones around secondary cities such as Ziguinchor, the capital of the Casamance, and Bignona, a town north of the Casamance River.

Fig. 3. Jola women transplant the rice seedlings.

Fig. 4. Young women harvesting rice.

In 1965, as part of an ongoing project on Jola rice cultivation practices, I collected all of the rice varieties grown in a small village of ≈600 people known as Jipalom. Located in the mixed rice and groundnut growing area north of the river, away from the most intensive zone south of the river where rice is cultivated as a monocrop, the inhabitants of the Jipalom community still planted several varieties of the African *O. glaberrima* species. The rice samples collected were then identified in 1966 by R. Portères, the renowned rice expert, who divided the sample into the two species and named their various subspecies and types. The results of his identifications are presented in the following outline.

I. *O. sativa* L., subspecies *O. indica* Gutschin (5 varieties and 11 types).
   A. Variety *mutica*, types *longi-perlonga* and *longa*.
   B. Variety *elongata*, types *medilonga* and *perlonga, perlongissima*.
   C. Variety *atrobrunnea*, type *longa*.
   D. Variety *gilanica*, types *medilonga, media, curta*.
   E. Variety *adusta*, types *longa, media, media/longa*.

II. Hybrids between *O. sativa L.,* subspecies *O. indica* and *O japonica* (three varieties, two types).
   A. Variety *amaura*, type *curta*.
   B. Variety *sepica,* type *media*.
   C. A cross between A and B.

III. *O. sativa L.*, subspecies *O. japonica* Gutschin (four varieties, five types).
   A. Variety *italica,* type *curta*.
   B. Variety *amaura*, type *media*.
   C. Variety *malanotrix*, type *curta*.
   D. Variety *dichroa*, types *media, media/longa*.

IV. *O. sativa L.,* subspecies *O. brevis* Gutschin (one variety, one type).
   A. variety *cycliana*, type *percurta*.

V. *O. glaberrima* Steudel (six varieties, including one hybrid, eight types).
   A. Variety *rustica*, types *curta* and *media*.
   B. Variety *rigida*, types *media* and *medilonga*.
   C. Variety *evoluta*, type *media*.

Fig. 5. Displaying the rice seed for exchange.

D. Variety *aspera,* type *curta*.
E. Hybrid between *aspera* and *rustica*
F. Variety *ebenicolorata,* type *media*.

In summary, 6 of 19 varieties, or nearly one-third of the rice that was grown in 1965 by the inhabitants of the Jipalom community, belonged to the African rice (*O. glaberrima*) species. Interviews with the elderly ladies of the community confirmed that in the not-too distant past they grew many more African rice varieties. Without the slightest hesitation they could name at least ten *O. glaberrima* varieties that were no longer planted. It is also quite probable that further south, in the more intensive rice-growing zone south of the Casamance River, the Jola were growing an even higher number of *O. glaberrima* varieties than in Jipalom in the 1960s. To this day, African rice varieties are known in Jipalom under the general terms "ajola" (from the Jola, their ethnic label), or "ecasay" (from Casamance), whereas types of the introduced Asian species are known as "amanding" rices, to indicate that they were brought in by the Manding peoples, a nation of traders with which the Jola have had protracted interactions through the centuries.

In Jipalom, it is the women who select the rice seed; it is they, and not the men, who can distinguish the different varieties (Fig. 5). A woman is able to recognize numerous rice varieties based on the size and number of grains in each spikelet, the red vs. white color of the bran and the stem, the shape of the panicles, and whether or not they have "spikes," which is a characteristic of the African types. The two species, *O. glaberrima* and *O. sativa*, are also easily separated on the basis of their morphology, and their growth and ecological features are well known. Thus, women know that the African types mature earlier, are usually direct seeded on higher ground rather than transplanted, and are hardier but lower yielding than the Asian types.

The Properties of Rice That Are Valued

Jola women place great value on the distinct ecological properties displayed by the numerous rice varieties belonging to the two species that they cultivate. First and foremost, they focus on their rates of maturation, whether varieties are fast or slow growing, followed by their height, whether the plant will be tall or short. It is important to grow a mixture of fast and slow maturing types so as to stagger the harvest. Tall varieties are easier to harvest than short ones, but they tend to lodge (i.e., to fall or lie down). Another criterion taken into consideration is whether a particular variety does well in clayey soils, or if it is better suited to grow in sandy soils. Because different kinds of soils are found in the various types of paddy fields (sandy soils in the nurseries, for example, and clayey soils in the *kuyelen* fields that retain rainwater) it is imperative that the right kind of seed or seedling is put in each sector of the rice fields. For these various reasons, Jola women constantly exchange rice seed with other women. A woman will trade a variety that is best suited to the rain-fed fields (the *biit*) for one that grows well in the mangrove fields (the *weng*). Another woman will trade a fast-growing for a slower-maturing variety depending on her needs. Trading varieties sometimes takes place over considerable distances, between women living in separate villages, so that rice seed circulates over wide spheres of exchange.

The cultural aspects that dominate Jola women's choice of which varieties to plant have to do with their taste, the ease with which they are pounded (or milled), and how they respond to cooking. A Jola can usually tell the general region from which a particular variety comes, and how long it has been stored, by its taste. Rice varieties from the southern Jola area tend to be "sweeter" tasting, except when they have been stored for a long time in granaries placed on the ceiling of the cooking huts; rice thus stored acquires a smoky taste. Jola women also prefer longer-grained rice, which is easier to pound, and nonglutinous varieties that they say are easier to cook. The kind of fractured rice that is imported from Southeast Asia that can now be bought in town stores is mainly consumed by rural Jola living north of the Casamance River. This is the more Islamicized area, where rice-production has diminished markedly since the years of drought. South of the river, however, the more "traditional" Jola reject this poor-quality rice, refusing to eat it. Curiously, they also reject the long-grained rice that United States aid agencies give to the Senegalese government to distribute in times of need. They say it has a "strange" taste, perhaps because it is milled by machine, and they are not used to it. In short, the preferences and patterns that the Jola articulate with respect to their preferred rice varieties reflect a wide range of reasoning, from ecological or environmental to cultural and, as we shall see, religious.

The Drought and Its Aftermath: Old Varieties Disappear and New Ones Are Introduced

In the late 1960s, and for several ensuing decades, many sub-Saharan African countries, including Senegal, entered a drought-ridden period. This meteorological disaster was not confined to the dry zones of northern Senegal. It was acutely felt even in the wetter, more tropical region of Lower Casamance to the south. In Bignona, a town close to the Jipalom community, rainfall for the month of June 1968 was only one-third that of previous years. August and September, crucial months when the rain-fed fields had to be tilled before transplanting, received $<$200 mm of rain each, compared with $>$500 mm the year before. October had a scanty 87 mm, compared with 100 mm and 238 mm the previous 2 years. The total precipitation for the entire year was 826.5 mm, compared with 1,795.1 mm the year before (1967). This was the first clear warning sign that many difficult years were ahead.

In fact, the mean precipitation for Bignona in the years 1968–1977 was insufficient, with 1,056.33 mm of rain, compared with 1,436.41 mm for the years 1958–1967. But drought years were not always in consecutive years. Whereas 1969 and 1970 had a satisfactory precipitation, 1971 and especially 1972 were deficit years. Rain gauges set up in the community of Sindian, very near to Jipalom, registered <1,000 mm in 14 of 20 years between 1973 and 1993. In 1980, the situation had been catastrophic, with 676 mm of rainfall falling in the entire year. Insofar as rice cultivation was concerned, the situation certainly qualified as an agricultural drought, when plants suffered seriously from lack of moisture. Conditions improved somewhat in the years after 1993. For example, precipitation in the Sindian area was 1,310 mm in 1994 and 1,435 mm in 1999. But the mean precipitation all over the Lower Casamance during the last decades has been several hundred millimeters below what it had been in the decades preceding the late 1960s.

The years of drought had a profound impact on the Jola agricultural system and, more specifically, on the farming practices of the Jipalom inhabitants. In this community, the deep and productive fields that had been carved from the mangrove (i.e., the *weng*) no longer existed. In their place was a salt-encrusted expanse of barren land. The *kuyolen* (with an "o") area, located behind the compounds, which in 1965 was entirely prepared as nurseries, was now definitely abandoned and overrun with weeds. It was substituted by a few nurseries made in the backyards of houses. Only one-third to one-half of the rain-fed or *biit* fields were being cultivated. The only paddy fields that could be counted on to yield a decent harvest were the *kuyelen* (with an "e"), where runoff rainwater accumulated.

One of the marked changes brought about by the rainfall deficit was the loss of many of the old rice varieties as new, fast-growing types were introduced by extension agents from national research centers such as DERBAC (Projet de Developpement Rural de la Casamance), and foreign development schemes such as the Dutch-financed ILACO (International Land Development Consultants) project. Thus, in 1989, only 13 varieties of rice were being grown in Jipalom, compared with 19 in 1965–1966. Of the 1989 varieties, three were old *O. sativa* varieties that had been around before, and the rest were new, fast-ripening *O. sativa* varieties that had been introduced in the preceding years. The inhabitants could name at least seven of the old *O. sativa* varieties that had been abandoned. Interestingly, only 2% or 15% of the varieties grown belonged to the African *O. glaberrima* species. Therefore, there had been a notable loss of diversity in the rice varieties being grown twenty years after the drought began.

Drought was not the only factor affecting rice diversity in Lower Casamance. Although difficult to measure, the protracted civil war that has brought endless confrontations between soldiers of the Senegalese army and Jola rebels of the MFDC forces (Mouvement des Forces Démocratiques de la Casamance) has caused the abandonment of several Jola communities in the southern sector, near the frontier with Guinea Bissau. The displacement of people and neglect of the rice fields must have caused several rice varieties to disappear, but we have no way of measuring the extent of this loss.

The loss of diversity was very marked in the agricultural year 1999–2000. In that year, only nine varieties of *O. sativa* were being grown in the village, and only one variety of the *O. glaberrima* species. Although some African types mature rapidly, their relatively low yields and difficulty in pounding or milling discouraged farmers from growing them. A woman who would have planted in the previous decades an average of seven to nine varieties would now plant only three. During the previous decade, government extension agents from DERBAC had begun disseminating high-yielding, fast-ripening *O. sativa* varieties all over Lower Casamance. In an adjacent village to Jipalom, for example, a resident extension agent would prepare a nursery plot, plant it with the new varieties, and give the seed and seedlings to Jipalom's farmers. The mainland Chinese, who were working on a small dam in a neighboring community, also introduced a few fast-maturing varieties.

The loss of diversity had negative consequences. The 1999 precipitation had been considerable (1,435 mm of rain), and it was well distributed throughout the year. But the fast-ripening *O. sativa* varieties that were to be harvested beginning in 2000 had matured all at the same time, making it impossible for the Jipalom women to gather the entire crop at once. Much of the crop lodged, rotted from the excessive water at the start of the season, or dried up when not gathered in time at the end of the season. Thus, despite the abundant rains, the severely restricted gamut of varieties planted by the Jipalom inhabitants had worked against them. This reliance on few varieties made farmers aware of the necessity during future years to plant some of the older, slower varieties to have widely spaced harvests.

African *O. glaberrima* Varieties Survive in Ritual Contexts

In communities north of the Casamance River, such as Jipalom, the inhabitants converted to Islam beginning in the 1930s. South of the river, however, in the wetter, more intensive rice-growing regions west of Oussouye, in the lands located at the entrance of the Casamance River, the majority of the inhabitants have remained practitioners of the traditional *awasena* religion (from *kawasen*, to pour palm wine libations at the shrines) (17). Here, traditions relate that the supreme deity, the rain "god" known as Emitai, gave "Diola rice" (*O. glaberrima*) to the ancestors. This rice carried a life-giving power that explained the ultimate origins of the land that Emitai had bestowed upon the inhabitants. For this reason, some varieties of *O. glaberrima* should always be planted, to preserve the link to the ancestors, and to Emitai, who sends rain.

The inhabitants of Sambujat, a small community of farmers who cultivate rice exclusively in the deep irrigated fields reclaimed from the mangrove vegetation, recall the time when their forefathers cultivated only the *O. glaberrima* species. This must have been at the turn of the century, before the *O. sativa* varieties were introduced. Today, very few of the old African rice varieties are cultivated. The exception, however, is the *O. glaberrima* variety called *ejonkin*. *Ejonkin* is grown in considerable quantities by the Jola living in four communities on the shores of one of the important tidal channels (or *marigots*) that extend inland from the entrance of the Casamance River. This marshy terrain is crisscrossed by *marigots* that create small islands where the people live and cultivate their rice fields. Because many of the fields are bathed by brackish water, the inhabitants like to grow the *glaberrima* species, which is tolerant of salt-saturated soils. The main function of the *ejonkin* rice is ritual, to propitiate the rain-shrine called Husurah. This important shrine must be propitiated with African rice; varieties of the Asian species cannot be used. Small quantities of cooked rice belonging to any *O. glaberrima* species, in this instance *ejonkin*, must be placed each year around the shrine to ask for abundant rains. The participants in the ritual, however, often eat cooked rice belonging to *O. sativa* varieties. Thus, what is eaten is kept separate from what is required in sacred rituals.

To propitiate their own version of the Husurah shrine, the inhabitants of communities such as Sambujat, who no longer cultivate the *O. glaberrima* varieties, must go to one of the aforementioned communities and trade 10 jugs filled with palm wine for one jug of *ejonkin*. The reasons given by the Sambujat people for no longer cultivating the African species is that its yields are low, and it is slow-maturing in comparison to some varieties of the Asian species, which mature in the record time of 65 days. Moreover, it is said that *O. glaberrima* varieties are difficult to thresh using one's feet because grains are arranged in

a row on the spine. And they are difficult to pound (i.e., mill) because the red bran cannot be easily removed, and are slow to cook. It is doubtful, however, that in former days, those who grew and cooked rice found it necessary to remove the bran, or to boil the rice for a short period. In any case, African rice is said be "heavier" on the stomach and hence better at quenching hunger. It also makes a good flour that is more aromatic and tastes better than the flour made from the *O. sativa* species. As a flour it can be consumed as a drink, as porridge, cooked as dumplings, or grilled over hot cinders.

To summarize, the ancient species of African rice survives in pockets of Lower Casamance, where the Jola employ it in sacred rites. This is a common occurrence. All over the world, old "traditional" cultivars are used in ceremonies to propitiate the spirits, for the link between crops and the ancestors is a fundamental pillar of most agrarian societies. The Mende peoples of Sierra Leone, for example, use African rice, soaked in palm oil, as a major component of their ritual sacrifices to the ancestor (6).

NERICA: New Rice Varieties Hold Great Promise for Sub-Saharan Africa

The new varieties, named "New Rice for Africa" (hence NERICA), are a cross between *O. glaberrima* and *O. sativa*. They combine the hardiness of the African species with the productivity of the Asian species. Scientists at the West African Rice Development Association (WARDA) succeeded in crossing the two species by employing embryo rescue techniques that ensure the crosses are fertile and mature successfully due to high levels of hybrid vigor (18). In doing so, they used seeds of African rice varieties that local farmers, many of them women from Guinea, grew in their fields, and incorporated them into gene banks. The farmers, in turn, provided information to the scientists about the traits that they most valued in the new hybrids. NERICA varieties shade out weeds, are resistant to pests and droughts, grow in poor soils, and mature 30–50 days earlier than traditional varieties. Moreover, they produce 400 grains per plant (as opposed to 75–100 in the older varieties), contain 2% more proteins and, as a bonus, are said to taste like African rice. The high productivity conferred on the NERICA strains by their Asian parents means that yields can be increased from the previous 1 ton per hectare to 1.5 tons without major inputs. With fertilizers and good care yields can double or even triple. Thus, the new rice holds great promise for a region in desperate need of decreasing hunger and increasing food security.

Tragically, food production in sub-Saharan Africa is diminishing by 1% a year. Per capita food production in 1966–1968 averaged 119 kg per person per year. By 1982–1984, it had fallen to 98 kg per person per year (19), and by 1993 to 91 kg per person per year (Table 8-5 in ref. 20). In 1999 it climbed slightly to 94 kg per person per year (Table 8-5 in ref. 21). As early as the end of the 1960s, population growth was outstripping the annual growth of agricultural production. Thus from 1965 to 1973, population grew by 2.7%, whereas agriculture grew by 2.4%; this relationship was 2.9% to 1.1% from 1973 to 1980, and 3.0% to 2.1% from 1980 to 1990 (22). "Africa is moving rapidly toward a third decade of declining food production and increasing population growth" (23).

In the 1960s, many African farmers were producing enough rice to feed themselves. Since then, yearly imports have increased 8-fold to 4 million metric tons (www.gene.ch/genet/2000/Mar/msg00063.html). The situation in Senegal illustrates clearly this shift from self-sufficiency to dependence on the market. Before independence, Senegal was importing rice from Southeast Asia, and later Mali. But this rice was destined for the cities; most rural rice-producing areas like Lower Casamance were largely self-sufficient. Rice imports for Senegal increased steadily, from 100,000 tons in the early 1960s, to ≈300,000 tons in the early 1980s (24). In the 1992–1993 marketing year, the cereal import requirements for rice was 400,000 tons, or ≈57% of all cereal imports. This amount increased to >557,000 in 1998 (http://primature.sn/lesoleil/rizimporte.htm). The broken rice that is imported is sold to wholesalers in Dakar and other regions, but clandestine trade is very important, with Gambian rice being found in all markets in great quantity.

The enormous scientific efforts that produced NERICA will result in a "Green Revolution" in which nearly 1.7 million West African farmers will benefit from increased food security. It will help their countries save millions of dollars in rice imports. The basis for this success story is to be found in those West African farmers who continued to grow the ancient *O. glaberrima* varieties of rice despite the introduction of the new Asian species. Their knowledge, expertise, and continued adherence to their traditional rice provided the basis for experiments that resulted in the creation of a promising new hybrid. Thus, both cultural and ecological variables entered significantly into these developments.

I am grateful to the reviewers for their helpful comments. This work was supported by grants from the Smithsonian Tropical Research Institute. Lina Gonzalez of the Smithsonian Tropical Research Institute photolab printed the figures.

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