COLLECTION AND OBSERVATION OF WILD RICE (ORYZA) SPECIES IN WESTERN INDIA. REPORT OF SURVEY FROM OCTOBER 1ST TO 28TH,1984.

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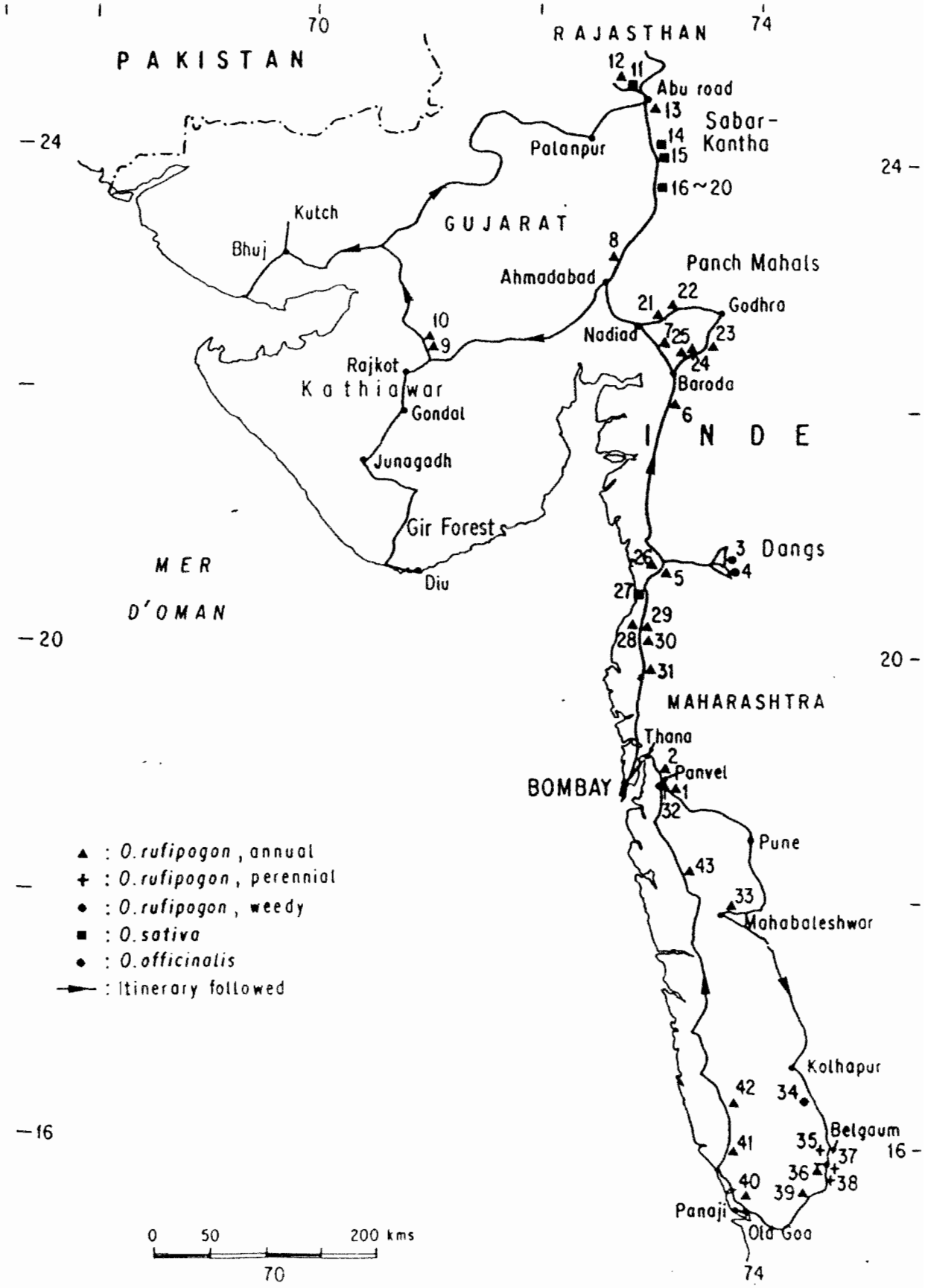
INTRODUCTION.

Wild rice - (Oryza) species are distributed in abundance in Asia from Central and South India to Southern China and the South-East Asian Archipelago. This distribution is probably the relict of a much larger one in Eurasia which has allowed the migration of wild rice from Asia to Africa (Second, 1985 a and b). The occurence of the direct ancestor of cultivated rice (O.rufigon) in Pakistan and Western India was reported in the litterature (Thadani 1928, Harlan 1975, Shah X and also in the collections of the Kew (London) and Blatter (Bombay) herbariums. Howewer, no sample from these areas was available in the living collections. As they may represent valuable germplasm, this visit was primarily designed to fill that gap as far as Western India is concerned.

On the other hand, Western India offers at least two particularities relevant from the point of view of the study of the origin of rice :

1) It is from Western and Central India that the oldest evidence of rice cultivation were found (Fairservis 1975, Allchin 1980).


70
74
PAKISTAN
RAJASTHAN
24
20
16
Abu road
Sabar-
Kantha
Palanpur
Kutch
Bhuj
GUJARAT
Ahmadabad
Panch Mahals
Godhra
Nadiad
Rajkot
Kathiawar
Gondal
Junagadh
Gir Forest
Diu
Baroda
INDE
3 Dangs
4
MER
D'OMAN
MAHARASHTRA
Thana
Panvel
BOMBAY
Pune
Mahabaleshwar
Kolhapur
Belgaum
Panaji
Old Goa
▲ : O. rufipogon , annual
+ : O. rufipogon , perennial
● : O. rufipogon , weedy
■ : O. sativa
● : O. officinalis
→ : Itinerary followed
0 50 200 kms
70
74

2) Rice is (at least at present) a minor crop in this area, compared to wheat and millets. Chances for hybridization between wild and cultivaded rices are thus lessened.

Altogether, 43 samples were collected, including :

28 O.rufipogon, annual form. Some of them were collected in areas without any rice cultivation or in high altitude (1400 m).

3 O.rufipogon, perennial form

1 O.rufipogon, weedy form

9 O.sativa found maturing nearby wild rice, including 3 samples of a primitive cultivar probably directly issued from the local wild rice

2 O.officinalis

Important observations were made, in particular on the following points:

- Distribution of O.rufipogon according to the soil type and climatic factors.

- Probable incipient domestication of local wild rice.

ITINERARY FOLLOWED

The itinerary followed is shown on the map attached. It is composed of two main loops starting and finishing in Bombay. The first one goes from Bombay to Ahmedabad with a deviation to the Dangs district, then to the peninsulas of Kathiavar and Kutch, to mount Abu in Southern Rajasthan and

back to Bombay. The second one goes from Bombay to Poona, then to Goa by the highway on the Deccan plateau, with a side trip to Mahabaleshwar area. From Goa, it returns to Bombay by the coastal highway.

Although the main highway were obligatorily followed,local subsidiary tripswere often made by car and by walk, according to :-

- information obtained previously to the trip (Dangs district: samples DO3 and DO4, mount Abu: DSII, DN12, DN13) or during the trip (Panchgani plateau: DN33);

- particularities in the soil type noted on maps (Legris et al):samples DN9 and DN10.

In these cases, inquiries to local people and their guidance were of invaluable help.

In other cases, as in the Gir forest and other forests in mount Abu and Goa area, local trips did not yield any sample in spite of intensive search and inquiries.

The itinerary followed by car was 5 600 km long, covered in 18 days at a mean speed of 40 km per hour. In other words, over 7 hours per day, during the main collecting trip, were spent in the car.

AN OVERWIEW OF ENVIRONMENTAL CONDITIONS AND NATURAL VEGETATION

The international map of the vegetation and environmental conditions edited by the French Institute in Pondichery (Legris et al) provided us the basis for the following overwiew.

Relief :

The area visited presents the Western Ghats forming an abrupt North-South barrier 1000 to 1500m high; the Western Ghats isolates from the basaltic Deccan plateau a littoral plain (or Konkan)which is narrow South of Bombay but becomes progressively wider in the North to the Gujarat. The Mount Abu in the North realizes the South-West extremity of the Aravalli range. To the West, the Gujarat continues in the Kathiawar (or Saurashtra) and the Kutch peninsulas with a few exceptions (Gir range, Barda hills,mount Girnar) the peninsula represents a very flat area whose complete fusion with the continent might have been realised only since the 17th century AD following continuous deposit of alluvion by rivers

climate :

climate is strongly under the influence of the relief and the Monsoon phenomena which comes to the

continent from June to October. Rains are heavy on the West of the Ghats in the mountains exposed to the wind and on the contrary much more scarce and with high annual variations on the slopes to leeward. The littoral zone of Konkan and the Ghats enjoy a tropical humid climate with an annual rainfall of 2000 mm on average but up to 5000 mm on the top of the high plateau (Mahabaleshwar) . The amount of rain per year diminishes progressively to less than 500 mm from Goa to Daman as the dry season increases from 5 to 8 months. South Gujarat is characterised by a climate of transition with 1000 to 1500 mm precipitations and a dry season 7 to 8 months long. Central Gujarat and Kathiawar are drier with 500 to 1000 mm rainfall and a 8 months dry season. A similar type of climate is found East of the Ghats and South of Rajasthan. Finally, the Kutch is very dry with less than 500 mm rainfall and a dry season at least 9 months long.
The temperatures are high. The mean temperature of the coldest month is generally above 20°C except in Central Kathiavar, the Kuch and on the Ghats where it is comprised between 15 and 20°C.

Various informations coming from geology,pedology, paleontology and relative to the evolution of the Harrapan civilisation lead to believe that all the concerned area was more humid in the past but has undergone drying recently.

Soils :

Besides climate and topography, pedogenesis is

influenced largely by the parent material constitued for the major part by so-called Deccan trap. Lateritic soils are found in the area of higher rainfalls in the littoral area and in the Ghats. They are characterised by free aluminium hydroxydes and an acidic pH.

Generally speaking they are highly elluviated. Particularly when shifting cultivation is practiced, they are highly eroded and a lateritic cap is sometimes exposed. The existence of some fossile laterite in Kathiawar gives evidence to the paleoenvironment more humid than in the present days.

Tropical red soils are found on slight relief when the rainfall is not in excess of 1800 mm. They are rich in ferric hydroxydes and bases and are generally shallow and poor in organic matter. On trap, they occupy all the hills (The Ghats Eastern slopes, Gir range, Barda hills in Kathiawar). Tropical red soils have also developped on acidic rocks (Satpura mounts, Aravalli mounts). They are dry, sandy and slightly acidic.

Black soils are linked to an horizontal topography which limits horizontal drainage and to alkaline rocks. They are characterised by a high pH and are rich in bases and fine elements .

Black soils on trap were formed under a climate with 700 to 1000 mm rainfall and a 7 to 8 months dry season. They are the most common soils in the area concerned. They occupy the major part of Kathiawar peninsula and the area from

Daman to Baroch which represents the extremity of the Ghats range. Black soils on alluvia are also found in the Eastern end of the peninsula from Baroch to Ahmedabad. They may be enriched in cations by deposit from the basaltic neighbooring areas. Black soil on alluvia are still richer in clay than black soil on trap. Generally deep, they represent good agricultural soils.

Loamy sandy or sandy-loamy alluvial soils are observed North-East of Gujarat till the Aravalli foot-hills. They are deep soils, permeable according to their sandy texture, with a pH neutral or slightly alkaline they may be rich in mineral but subject to eluviation. In the dryer areas, evaporation can develop salty layers.

Vegetation

Kathiavar's vegetation is marked by dry climate and is characterised by the vegetation association Accacia-Capparis which changes to a series Salvadora-Prosopis in Kutch. This vegetation type is actually very much disturbed by land cultivation, over grazing and the exploitation of wood for fuel; it subsists only as discontinuous thormy thicket characterised by the presence of Euphorbia caducifolia which is able to grow even on rocks outcrop.

In the hilly areas of Kathiawar where the rainfall reach 800 mm, series adapted to more humid environment are observed (Anogeissus-Terminalia) as for example in the dry

savanna forest of Barda Hills.

Other vegetation are more humid types and depend on the position of teak in the association. The Anogeissus-Terminalia-Tectonia corresponds to a rainfall of 1000-1500 mm on ferrugineous tropical soil and is observed in the East of Gujarat (Surat, Nasik, Dangs, Panch Mahals districts); it alse appears sporadicaly in the hilly areas in Kathiawar (Gir, Girnar hills). The natural vegetation constitutes a dry teak forest which is found only in the preserved areas; elsewhere, the exploitation of forests and shifting cultivation have led to a tree and shrub savanna. This last vegetation type is also found on the Deccan plateau on the other side of the Ghats. Slightly moist teak forest is found in the district of Dangs, Thana,Nasik and Bulsas; they are linked with higher rainfall (2000 mm) on ferralitic soils with 7 to 8 months dry, Relief and water capacity play a determinant role in the observed vegetation.

Humid and very humid vegetation types are subjected to the influence of the Ghats on rainfalls. It is possible to distinguish vegetation stratas according to altitude, lenght of dry season and the mean temperature of the coldest month. On the littoral, a moist teak forest predominates. Above 600m, teak is replaced by Ficus (Bridelia - Syzygium - Terminalia - Ficus series) which is adapted to cooler temperatures. On the crest of mountains but locally, very humid formations are observed. They present a maximum development in Mahabaleshwar. Moist deciduous and moist

semi-deciduous forests are found only as relicts in inaccessible zones.

Agriculture

Agriculture is dependant on the Monsoon climate which allows cultivation during the rainy season (Kharif season) and according to the availability of irrigation also during the dry season (Rabi season).

Generally speaking, in the area concerned, rice is not a dominant crop, particularly in Gujarat, compared with its importance in the Eastern and Southern provinces of India.

In the moist teak forest, shifting agriculture is practiced. It concerns rice and various millets: finger millet (Eleusine coracana), little millet(Panicum miliare), common millet(Panicum milliaceum) as well as foxtail millet(Setaria italica),kodo millet (Paspalum scrobiculatum) and barnyard millet(Echinochloa frumentacea

Cotton, peanuts and tobacco are the main cash crops. Besides peanuts, other oleaginous crops are also found: Guizotia abysinica (Niger) , Sesamum indicum , Ricinus communis . Vegetarian customs have led to a large importance of various beans and peas which are cultivated in the dry season, after the grain crop in the wet season moth bean (Vigna aconitifolia),pigeon pea(Cajanus cajan ,lablab bean (Dolichos lablab), black gram (Phaseolus mungo), mung bean (Phaseolus aureus), chick pea (Cicer

aretinum). In the Kathiawar, the exploitation of numerous forage shrubs and trees is important (Prosopis juliflora , Prosopis spicigera , Cassia fistula , Accacia senegal , Albizzia procera , Dalbergia latifolia

Rice is generally a crop of the monsoon season. In Gujarat it is localized in the south (Bulsar and Surat districts). Its importance decreases in Broach and Baroda districts. Irrigation is practiced particularly in the years of insuficient rainfall. African millet (Penisetum americanum) sorghum, corn and wheat are the other main stapple crops. In the Kathiawar, Kutch and the North Gujarat, where the climate do not allow rice cultivation, these are the main crops whith peanuts.

In the littoral areas of Konkan, rice is the basic stapple crop. To the East of the Ghats, the importance of rice is much reduced (0.5 to 3 % of the arable land).

WILD RICE SPECIES

1) An overview

In India, the following species of wild rice are found: O.rufipogon griff, both annual and perennial life forms, O.officinalis Wall ex Watt, both diploid and tetraploid forms (=O.malampuzahensis), O.meyeriana Zoll et Mor. ex Steud, O.Coarctata Roxb (= Porteresia coarctata Tateoka).To the knowledge of the authors O.meyeriana has never been reported from the area visited. We did not not observed it either. O.coarctata was reported in the salty

marshes, particularly in the Indus delta. We search for it in Kutch peninsula but dit not find it. O.rufipogon and O.officinalis were collected.

Besides, the closely related species Leersia hexandra and Hygroryza aristata were reported from the area visited. L.hexandra was found in sympatry with the perennial form of O.rufipogon. No seed sample could be collected.

Hygroryza aristata is a floating grass, forming pure mats on the surface of water. The grains are gathered and eaten by the poor. "They are reported to be sweet, oleaginous, digestible and cooling and useful in biliousness "(Sastri 1959). It has several vernacular names, including "Deo Bhat", the "rice of god", also given to O.rufipogon and O.officinalis. It was reported in floras and from herbarium specimens in many places, including in the area visited. Although we observed, carefully, supposedly some of the exact places (as in Khandala Talao between Bombay and Poona), no plant was seen. The reason for that (pollution, competition from newly introduced exotic species,inappropriate season, others) are not clear.

2) O.rufipogon.

It was reported many times nearby Bombay in places now included in the suburbs. We found it frequently along the coast, generally down the Ghats from Goa to Ahmedabad but also on the Panchgani plateau (Alt. 1400 m), always on ferrugineous or ferralitic soils. It was not observed on

black soils on the Deccan plateau nor Kathiawar and Kutch peninsulas. In Kathiawar, it was however found in a small area occupied by ferrugineous soil.

Besides 4 samples found in the latitude of Goa, all samples appeared to be of the annual type in the sense that all plants most probably were going to die soon after maturity. They looked remarkably similar to O.breviligulata in Africa with seeds often bigger than cultivated ones, and long and stiff awns. They had however a long ligule. The habitat of these annual forms was always a temporary (rain fed) pool, either natural or created by the construction of a road or a dam.They were sometimes observed near rice fields but never as a weed in rice fields.

The time of visit corresponded generally to the peak maturity.

Four samples did not belong to the typical annual wild form. One was found as a weed in rice fields and was probably introgressed by genes from O.sativa (DN 34). It had long awns, matured earlier than cultivars in the same field and shattered easily.

Three samples belonged to the perennial life form of O.rufipogon. Their awns were less developped and their spikelets smaller than in the annual type. They were flowering or beginning to mature at the time of the visit. No rhizome was observed. It is primarily their similarities, (in the outlook) with perennial types studied in experimental fields or green houses which allowed their

classification as perennial type. As they were found in the latitude of Goa, where the rainy season last longer, and were accompanied by perennial species as Leersia hexandra, there is little doubt on their pereniality. In other words, during this trip, the perennial and annual types of O.rufipogon could be unequivocally distinguished in the wild. Whether or not they represent two different species (annual form = O.nivara Sharma and Shastry ?) requires however additionnal observations.

Additional remarks or items of description can be found in the list of samples.

3) O.officinalis.

Although we looked for O.officinalis in all forested area we went through, i.e. Gir forest, mount Abu, Dangs district and the Western Ghats, we found it only in Dangs district where it is reported in the Flora of Gujarat state and in herbariums.Out of the three sites documented i.e. Waghai-Pimpri road, along Nasik road and in Bansda, side of river, we found it only in the first one. We found however another site (DO4) deep in the forest, after walking guided by a local farmer. The species thus appears to be quite rare in the area visited. We therefore suggest that care should be taken to protect it and to introduce it in suitable sites from seeds taken on the populations which exist in Dangs district.

The two sites observed were under deep shade with small populations on moist soil and, in one case, a

a (probably seasonal) spring. (Additional details are in the list of samples: D03 and D04).

Judging from preliminary electrophoretic studies the two samples are of the diploid form.

CULTIVED RICE.

As stated in the introduction, collection of cultivated rice was not the primary goal of this mission. We made however some observations on traditional cultivars and found some primitive cultivars which deserve particular interest.

1) An overview.

In most of the area visited, rice is a rather minor crop. In the latitude of Goa however, rice becomes a major crop. There are several cropping seasons and most of the fields seen were either harvested or not matured. As the collection of cultivars is undertaken by other institutions and our time was limited, we collected only some of the cultivars which were found in the vicinities of the wild populations sampled and which flowered at roughly the same period.

Two observations seem to be worth mentionning. They remarkably parallel those made in other tropical areas, Africa in particular.

a) Cultivars in the fiels were often found to be very heterogeneous. That was particularly true in areas marginal for rice cultivation as in Bombay area but also, to a lesser extent, in Sabar-Kantha area in Gujarat and in Goa.

Possibly, this has something to do with the adaptation of the cultivars to their environment, including parasites.

b) Advanced farmers in Goa amazed us, together with Mr Dhua from CRRI, in saying that they cultivate only their own traditional cultivars although they are aware of improved varieties. The arguments put forward were, as often in similar cases, the followings : their rice is more nutritious, better tasting, it is less susceptible to diseases and gives a more stable yield over years. We feel totally unable to ponder these arguments and to discern the reason for this situation which should however give food for thought to those interested in rice breeding.

2) Primitive cultivars observed

In Sabar-Kantha area (Gujarat), between the villages Makamchampa and Idas, we noticed three populations (DS14, DS15, DS16) in artificial ponds which looked like typical annual forms of O.rufipogon although they were more homogeneous in their maturity. We were told that these had been sown and were cultivated.

Panicles were however erect as in O.rufipogon, annual form. Spikelets were awned and easily shattered. Easy shattering is known to be common among the Indica type cultivars and was particularly noticed in the traditionnal cultivars (typical O.sativa) in the fields of Idar. It is thus compatible with domestication.

These primitive cultivars were reputed to be high yielding and non sticky on cooking.

A letter of Mr Dilip Gohil, who accompanied us at this time, tell us that those people who grow this rice are former "Intouchable" people.

Preliminary electropheretic analysis show :

a) Zymograms of the annual form of O.rufipogon collected in this trip are relatively close, but not identical, with those of conventional Indica cultivars of O.sativa.

b) Zymograms of the above described primitive cultivars are identical with those of O.rufipogon in the same area.

It would seem consequently that these primitive cultivars are directly issued from the local wild rice. Our impression is that, subsequently to the formation of artificial ponds, poor farmers broadcasted wild rice to get a crop.

It remains to be verified whether seeds are broadcasted every year and if there is any other cultivation practice (preparation of soil, weeding out etc...). However, preliminary observations, in winter season, in green houses in Montpellier show that theses plants :

- flower earlier than O.rufipogon originated in the same area
- have a more erect stature
- have shorter awns

It would seem that several generations under cultivation pressure would be needed for such a change toward domestication. It is thus possible that these

populations give an idea of the first step toward domestication which, in the case of rice, does not involve any drastic change in the architecture nor physiology of the plant.

CONCLUDING REMARKS

Although Western India had received little interest for wild rice germplasm collection and the success of this collection tour was not a priori guaranteed from the information available, it appears that the balance of results is largely positive.

As a matter of fact, we verified that O.rufipogon is not common in this area, exept along the coast, down the Western Ghats. It is very rare or absent in Kathiawar and Kutch peninsula. However we probably pin pointed the main factor for its distribution. It is not likely the climatic factor but rather the soil factor. O.rufipogon was found on acidic substrate such as ferrugineous or ferralitic soil (red soils) but not on black soils ("vertisols", "cotton soil"), more alkaline. From this observation, the factor determining wild rice species distribution in the Lake Chad, in Africa area where black soils are also found should be checked more carefully. It is not evident whether the soil pH itself is the determining factor. On the other hand, as red soils are common in Southern Pakistan, it should be checked whether annual O.rufipogon is not distributed in the wild in Southern Pakistan as well.

Another observation merits comments. Only the annual form of O.rufipogon was found above the latitude of Goa. This would seem to correspond with the short rainy season occuring in Western India. However, perennial form of O.rufipogon was not found on the Panchgani plateau at 1400m

altitude where the pond (DN33) was partly perennial. Possibly, there, the temperature is a limiting factor in winter season in th season. However, in Africa, where the distribution of the annual form (O.breviligula) is restricted to the short rainy season savannas, the perennial form (O.longistaminata) is also found sympatric with it although much more common in the humid savannas. In Western India, the two forms were never found in sympatry. The reasons for this situation are not clear.

The annual form of O.rufipogon observed appeared extraordinarily similar to O.breviligulata in Africa. This is unlikely a result of phenotypic convergence as the annual form of O.rufipogon in Australia is morphologically much more divergent. It rather goes for the hypothesis of a larger paleo-distribution of this annual type, extending from Asia to Africa. This area of distribution was split up some 2 million years ago when the possibilities of migration between Asia and Africa where interrupted, because of the shift in climatic zones (Second 1985 a and b). This hypothesis will be further checked by analysis of isozymes in the collected material.

Many of the samples collected were found far from rice fields. They represent valuable germplasm for rice genetic resources but also to study some aspects of the genetic and the origin of rice such as the genetic differentiation between annual and perennial form of O.rufipogon and the isozyme diversity of O.rufipogon

compared with O.sativa.

Another interesting observation was that of some primitive cultivars very closely related to the local wild rice although doubtless under some cultivation selection pressure. This goes for the hypothesis of a diffuse origin of cultivated rice. The area of origin of Asian rice should not be restricted to the foothills of the Himalaya as often advocated. It rather corresponds to the probable area of distribution of wild rice at the time of domestication (Neolithic epoch). As far as the Indian Sub-Continent is concerned, it may be ascertain that the area of domestication of rice also extends to Western India. If we think in terms of paleoenvironment, this becomes even more plausible. Before the development of agriculture and intensive deforestation, Western India was more forested. It could be that, at the time when domestication started, accumulation of an organic stratum over the underlying soil provided larger habitat and distribution of O.rufipogon . As a matter of fact, it appeared to us that the pools on red soil in which we found O.rufipogon where richer in species diversity than the pools on black soil in which there was no O.rufipogon. This could be indicative of a recent change in the ecological conditions on black soil. However we could not confirm nor precise the above observation in the time available.

Pr. Legris and collaborators (Legris et al) studied the distribution of vegetation in India but at rather small and medium scales and so, the details concerning the pools and

puddles have been overlooked.

A study by Dr.V.M. Meher Homji of plant communities in fresh water ditches, swampy areas and fallows around Bombay gives some interesting indications in that vein. During the monsoon (rainy) season, the rains seem to favour an equal number of species (12-13) in the community, both on black clayed and red fine sandy loam soils. However, a striking difference was noted in the number of species during the dry cooler season (Meher - Homji 1969 and Pers. Com.):

Average 6 to 7 species on black clay soil

Average eleven species on red fine sandy loam.

The above observation do not give support to our observations which are perhaps somewhat superficial. However, we beleive in thinking in terms of paleoenvironment when judging the possible role of Western India and the Indus Valley in the incipient domestication of rice. This aspect remain to be studied in more detail.

Acknowledgments.

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Dr. S.M. Almeida, Director of the Blatter herbarium in Bombay and Dr. P.K.Ranjekar, project leader in plant molecular biology at the National Chemical Laboratory in Poona helped us in many ways in setting up our trip. We appreciate it particularly since one of us (G.S.) had all his luggage stolen at the time of departure in France and the mission would not have been possible without this strong support. Dr.V.N.Misra, Deccan College, Poona, Dr.D.P. Agrawal, Physical Research Laboratory, Ahmedabad,; also provided us much advice, information and help. Dr.S.D.Sharma from the Central Rice Research Institute in Cuttack provided us good information prior to our trip on the distribution of wild rice species. We bitterly regret that basic difficulties in communication and the delay, unknown to us, of Mr. S.R. Dhua from C.R.R.I. to begin his trip resulted in many troubles for him before he could finaly join us, which we appreciated very much.

Three other persons accompanied us during part of

the trip, Mr. Ota from Deccan College, Mr. Dilip Gohil from Physical Research Laboratory and Miss Preeta Muthalali from Pune University. Many other persons helped us along our way. It is a pleasure to express our thanks to the Institutions, or people who made this trip possible and fruitful .

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Brief log of trip.

Sept. 30	Leave Montpellier and Paris. All luggage of one of us (G.S.) were stolen, including some documents, sample bags etc...
Oct. 1	Arrive Bombay 7. a.m. Fix for missing luggage. Make phone contact with Pr. P.D. Ranjekar in Poona. Visit Blatter herbarium, Pr. S.M. Almeida, St Xavier's college.
Oct. 3	Leave to Poona by train 3 P.M.
Oct. 4 and 5	Stay at National Chemical Laboratory in Poona. Visit Pr. Ranjekar. Send a telegram to C.R.R.I. to give a meeting point with Mr. Dhua at Physical Research Laboratory in Ahmedabad. Reserve a car for the trip. Visit Pr.V.S.Misra, Dpt. of Archeology, Deccan University.
Oct. 6	Leave by car to Thana and Daman. Stay in Daman accompanied by Mr. Ota, Ph.D. student at Deccan University in Eco-Anthropology.
Oct. 7	Visit Dangs district. Meet Mr. Gangurdi. 4 hr walk, (Satapura). Stay in Satapura.
Oct. 8	Leave to Ahwa, Surat, Ahmedabad. Stay in Ahmedabad.
Oct. 9	Visit Pr. Agrawal, Physical Research Laboratory. Visit Forest departement in Gandhinagar. Botanical Department Ahmedabad University.
Oct. 10	Mr. Ota returns to Poona by bus. Mr. Dilip Gohil, technical assistant in National Physical Laboratory comes along in Gujarat. Party leaves to Gir forest via Lothal archeological site.
Oct. 11	Visit Gir forest, Diu and return to Gir.
Oct. 12	Leave to Buj via Rajkot. Side trip in a ferrugineous soil area in Wankaner district. Meet Mr. Deva Rana Parmar. 3 hr malk.
Oct. 13	Side trip in Kuch from Buj. Return to Buj.
Oct. 14	Buj to mount Abu via Tharad and Palampur.
Oct. 15	Recruit Mr. Ranaji, local herborist. Visit Mr. Abu area by car and on foot.

Oct. 16	Mount Abu-Ahmedabad via Ambji, Kuroj. Side trip toward Ranivara from Abu rood. Inquiries on local rice cultivation practices in Idhar. Mr. Gohil stays in Ahmedabad.
Oct. 17	Ahmedabad - Daman - Side trip to Godhra.
Oct. 18	Damar - Bombay. Meet Mr. Dhua from. Central Rice Research Institude in Cuttack who joins the party.
Oct. 19	Stay in Bombay. Threshing of samples.
Oct. 20	Bombay - Poona by car.
Oct. 21-22	Stay in National Chemical Laboratoty. Visited Agricultural College, Botaical survey of India, Botanical department, University of Poona.
Oct. 23	Poona - Kolhapur. Side trip to Panchgani plateau and Mahabaleshwar.
Oct. 24	Kolhapur - Belgaum - Goa - Side trip from Belgaum on the way to Savantyadi.
Oct. 25	Visit the various ecological environments in the Goa area. Inquiries to people on local practices in rice cultivation and wild rice.
Oct. 26	Goa - Bombay - Main coastal road.
Oct. 27	Stay in Bombay-Threshing of samples. Mr. Dhua leaves back to Cuttack.
Oct. 28	Bombay - Paris at 1 : 40 a.m.

Rice populations sampled and their habitats

A share of all material collected was left to the Central Rice Research Institute (CRRI, Cuttack, Orissa) in charge of Mr. S.R. DHUA. The remaining part will be divided between ORSTOM (France and Ivory Coast) and the IRRI in the Philippines. An electrophoretic analysis of all samples collected is underway by ORSTOM.

Items of description

Acc. N°. (as registered at ORSTOM):

- D : stands for India
- N : *O. rufipogon*, annual type (*O. nivara*)
- R : *O. rufipogon*, perennial type
- W : *O. rufipogon*, weedy type (*O. spontanea*).
- S : *O. sativa* : cultivars.
- O : *O. officinalis*

Date of collection : for ex 6/10 = 6 October

Place of collection

Latitude. Longitude. Altitude.

Description and observations

Except DR 37, all samples were collected in the form of a bulk of seeds taken at randon on more than 50 plants or collected on the ground in the total area of the population.

DN1. 6/10. Nal. Hwy.4 Poona-Bombay. Mile stone
90/200. 8 miles after Khopoli
18°50N 73°15E Alt 150m

Pond (Ca. 300 m2) between the road and a rice field. Plants on the fringe of the pound, not in the deepest part (Ca 80 cm at the time of the visit).

Together with *Panicum* sp. and other plant species. No other *Oryzeae* species.

Beginning of maturity. No trace of introgression with *O. sativa* noticed.

Very stiff and long awn, big spikelets.

Ca 50 % of the panicles were attacked by borers.

This population seems to correspond well to the large seeds herbarium samples collected in the past in the Borivili National Park and other places in Bombay and Thana districts, as seem in the Blatter (Bombay) and the (London) herbariums.

It represents a typical annual life form of O. rufipogon, much similar to O. breviligulata from Africa, except for the ligule which is long and acute.

DN2 6/10 Nal. Hwy.4 - Poona - Bombay. 40 km before Bombay.
19°05N 73°05 E < 150 m

Large pond and swampy area in Bombay suburb, much disturbed by man and cattle. Ca 0.20 to 1m depth. Large, subdivided population. Together with water lilies (Nymphaeaceae), water hyacynths (Eichhornia sp.) and other species.

Beginning of maturity.
Red and white awned plants in patches.
Smaller spikelets and shorther awns than DN2.

DO3 7/10 Waghai to Pimpri road. Dangs district.
Preservation plot N°4
20°35N 73°35E Ca 900m.

Small population on the fringe of a forest preservation plot. Under shade of large trees and bambous. Plants scattered over a few hundred m^2. Humid, highly organic soil. No free water. No other population was found in an exploration of part of the plot (20 ha in total).

Maturity highly heterogeneous : some seeds had already shed, other spikelets were flowering and some were at maturity. Complete fertility.

Variability for red and white stigma. Awnless. Rarely very short awn. Plants Ca 1,50 m high.

DO4. 7/10. Ahwa area. Dangs district.
21°40N 73°35E Ca 900 m

Guided by a farmer, Mr Mangu Kolghà Gàngurdi (Ex Chief of village = Sarpanch).
Village Bhisia. P.O. Gundàlabhir. Talak-Ahwa. Dangs district. Gujarat.

This farmer who happened to know very well the area said it was the only population in this area. It is situated after Ca 3 or 4 km on foot, near a small village named NIL SA KIA. Every body of this village knows about the site but very few other people do.

Ca 100 m2 swampy area with a (probably, seasonal) spring. Under deep shade. Nearly monospecific.

Beginning of maturity. The best season to collect seeds should be at the end of October or beginning of November.

Same appearance as DO3

It is called under the general name for wild rice (including also Hygroryza) : "Deo Bhat" meaning "rice of God". It is sometimes harwested, particularly to use as medicine. Also appreciated as fodder by wild and domesticated cattle. The straw is also used to make thatched roof.

DN5 8/10 Ahwa to Surat road.
4 km before Rankuwa
20°45N 73°00E <150 m

Large pond in a seasonally swampy area, nearly dried up. Besides the road. Rice fields at proximity.

Most plants belong typically to the annual wild form but a few plants appeared to be clearly introgressed from cultivars.

Peak maturity. No pest or parasite noticed.

DN6 8/10 Bombay to Ahmedabad road.
Between mile-stone 153 and 154
22°05N 73°05E < 150 m

Small pond alongside the road. Only few populations were seen in this area.

Brown spots on leaves, probably Helminthosporium.

DN7 8/10 Baroda to Ahmedabad road
Mile stone 120-121
20°30N 73°00E < 150m

Small pond between road and rice field.
Population much introgressed by O. sativa.
Some plants partially sterile. Plants of wild type were chosen.

DN8 9/10 10 km from Ahmedabad on the way to Gandhinagar
23°10N 72°45E < 150 m

Small pond. 20m off the road. Dried up.
No rice field around but highly disturbed by cows.
Plants are short with spread tiller (not erect).

A remarkable peculiarity of this sample is that the secondary branches of the panicles are not spreading but on the contrary tied and sticked together. In this way, spontaneous shedding is reduced. This could enhance the dispersal of seeds by big animals. It should be studied whether this phenomenon could be a response to water stress which would promote dispersion toward a more suitable environment.

DN9 12/10 Ahmedabad to Kanla
12 km after the crossing to Rajkot
1 km on foot, North of village Garida
22°30N 71°05E < 150 m

This population and the following one are the only populations which could be located in Kathiawar and Kutch peninsulas. They were discovered, after intensive inquiries, in this particular area which presents the peculiarity, apparent on soil maps, to have red soils in place of the black soil most common in these peninsulas.

Guided by Mr Deva Rana Parmar
Village Garida
P.O. Mahika - Taluha
Wankana district
Gujarat.

Pool (Ca 1000 m2) on ferrugineous soil on sand stone. Soil sandy loamy.

O. rufipogon is the dominant species on the fringe of the Pond only. The plants in the deepest part (Ca 0.80 m) were completely matured and died while the plants on the shallower part were beginning maturity. Typical annual form.

Abundance of nenuphars in blossom and fruiting.

Vegetation around the pool : scattered srubs (Euphorbia caducifolia in particular), short gramineous cover or barren soil. Hardly any rice field in the area and not in the immediate vicinity.

Spikelets of medium size. Many were collected after they had dropped on some large sand stone with anfractuosities.

Brown spots common on leaves, probably Helminthosporium.

Vernacularname : Ad bameli

DN10 12/10 Ca 5 km from Village Garida (See DN9).

Similar pool as DN9 but shallower and more disturbed by cattle. The vegetation insides comprises abundant Cyperaceae and, around the pool, the Euphorbia is

replaced by Acacia.

End of maturity.
No disease nor pest noticed
Same morphological type as DN9

DS11 15/10 Mount Abu 1200
24°60N 72°80E Ca 1800 m

Rice field along a swamp. Badly cultivated.

Looks like a weedy type but seems to be cultivated as the same variety was observed in different rice fields. High sterility, easy shedding, awned, low exersion, large diversity among plants.

No regular cultivated variety observed in the area.

DN12 15/10 Mount Abu 1200
24°60N 72°80E Ca 1800 m
Guided by Mr. Vakto Ram Ranaji
Bakti Bhavan
Rajendra road
Mount Abu
Rajasthan

Three small ponds along a temporary stream. Sandy loamy soil on quartzite stones. Dried up. Highly disturbed by cattle.

Other plants include Echinochloa sp., water hyacynths (Eichhornia sp.) other Gramineae (Panicum sp. ?) and Cyperaceae.

Some panicles were partly sterile. This could be due to water or temperature stress ? No other sign of introgression from cultivated rice. No rice cultivation near by. Not common in the area. Could be escaped of fields such as DS 11 ?

DN13 16/10 Abu Road to Raniwara
7 km from Abu Road
25°00N 73°00E Ca 500m

Small pound (Ca 150 m2) along a small road. Drying up. Soil argilo-gley.

Dominant species with water hyacynth and Cyperaceae. Vegetation around the pool : Ficus(?) sp. Acacia, Tectonia.

Similar to DN1

Vernacular name : Sahul.

DS14 16/10 Road from Abu Road - Ambji-Kuroj-Ahmedabad
Km 23 from Ambji
Village Makamchampa
24°10N 73°00E Ca 200-500m

Artificial pond (Ca a few ha) on granitic sand. (0 to 60 cm deep).

Primitive cultivar : much similar to the wild rice of the same area, although it has a synchronous maturity. Also similar to the weedy type found in Tanzanian islands (Zanzibar, Pemba) and called "Pururé".

Beginning of maturity. Panicule straight up as wild rice, awned, easy shedding. Some plants are of the floating type with adventicious roots in the deeper part of the pond.

It is reputed to have been selected in the past by "Intouchable" people.

DS15 16/10 Ambji to Ahmedabad road.
Ca 90 km from Ahmedabad
23°50N 73°00E Ca 200-500 m
Analogous to DS14

In a small pond between the road and a cultivated field. Looks wild except for the synchronous maturity. It is

said to have been sown. The rice fields around are at tillering stage.

DS16 16/10 2 km after DS15 on the way to Ahmedabad.
Village Idar
23°40N 73°00E Ca200-500m

Large artificial pound
Shallower part (Ca 30 cm) looks cultivated
Deeper part (Ca 30 cm) looks wild with many weeds but is reputed to be cultivated.
Cultivar with the same appearance as DS14 and DS15 but near complete maturity.

DS17 16/10 Village Idar - See DS16-
January 1984 harwest. Mixted varieties " Kamod" and "Sarahu" (red).

DS18 16/10 Village Idar - See DS16
Variety "Sarahu" (red rice) in an irriguated rice field. Fully matured. Easy shedding.

DS19 16/10 Village Idar-See DS16
Variety "Har". Heterogenous : red and white pericarp, awned, black and yellow spikelets... Easy shedding.

DS20 16/10 Village Idar-see DS16
Irriguated rice field-Dried up.
Variety "Dangar".
High sterility. Easy shedding
Other rice fields arond DS18, DS19 and DS20 are still irriguated for an harvest in January.

In the same village Idar, a natural Pond on granitic sand was seen with O. rufipogon (or a primitive variety such as DS14 and DS15) highly grazed by cattle. Grazing could be a factor limitating O. rufipogon in some

places. No sample could be taken.

DN 21 17/10 Kheda to Godhra road
Village Uansol
22°42N 73°OOE < 100m

Swamp between road and unmatured rice field. Typically wild annual type. Water Ca 50 to 80 cm deep. Medium to big size spikelets. Abundance of Ipomea sp. large diversity for date of maturity.

DN22 17/10 Kheda to Godhra road. Village Timba-Udlpur
22°47N 73°25E <100m

Large natural pond on fine sand stone. Typical annual form. Complete maturity. Mixed with Joncaceae.

DN23 17/10 Gohdra to Baroda road. 20 km before Baroda
22°35N 73°35E <100 to 200 m

Very small population in a pond on the side of the road. Much grazed by cattle.

DN24 17/10 Gohdra to Baroda road
15 km before Baroda
22°2ON 73°2O E < 100m

Small natural pond Ca 100m off the road. No rice field around but only grazed savannah. O. rufipogon would probably be more frequent in this area if not overgrazed.

DN25 Another small population Ca 100m apart from DN24.

DN26 17/10 Surat to Bombay road
Between Chikli and Dhand
20°45N 73°05E <150m

Large natural pond. Typical annual form on the periphery only. Large diversity in the maturation time. About peak maturity.

DS27 18/10 Daman
20°25N 72°55E 150m
Irriguated but dried up rice field. Heterogenous variety. Some panicles are partly sterile.

DN28 18/10 Surat to Bombay road
125 km from Bombay
20°18N 72°55E <150m

Small natural pond. Typically wild annual form. No sign of introgression from cultivars. It is surrounded by rice fields with late maturing cultivars.
Fully matured.

DN 29 18/10 Surat to Bombay road
108 km from Bombay
20°18N 72°55E < 150 m

Small pond along the road. A thin sandy soil over rocks (sand stones ?). Vegetation around dominated by Tectonia. No rice field in the area.
End of the maturity period.

DN 30 18/10 Surat to Bombay road
68 km from Bombay
40 km from DN 29
19°80N 72°55E <150 m

Same type of small pond as DN 29 .

DN31 18/10 Surat to Bombay
1 km before Kalola
19°50N 72°55E <150m
Large pond on basalt soil.

Typical wild annual form. The leaves have a particularly green coloration. Beginning of maturity.

DN32 20/10 Bombay to Poona road
Mile stone 114/800
Panwel area
19°00 N 73°06 E <150 m

Large pond. O. rufipogon on the fringe only. Mixed with Nymphaceae and other Gramineae.
Panicles particularly open.

DN33 23/10 Panchgani area
5km North of Ambred village
Ca 17°55N 73°10E 1400m alt.

Large pond on a plateau, highest point in the area. Ferralitic soil on vacuolar basalt.

O. rufipogon is found in the shallowest part which dries up in winter while the deepest part is in perennial water. Big spikelets. Peak maturity. Typical annual form.

The vegetation in the pond is not dense. It is composed mostly of O. rufipogon and Joncaceae. A type of Plantaginaceae is found all around the pond.

Another similar pond is said to be found on another plateau across the valley but it is without

O. rufipogon. No other population of wild rice is known in the area.

This population was found on the base of an herbarium specimen kept at Botanical Survey of India in Poona and after prolonged inguiries in the area. It may represent the higher altitude population kept in living collection at the moment.

DW34 24/10 Poona to Belgaum road
Ca 30 km after Kholapur
16°20N 74°20E 500-1000m

In a rice field, on loamy ferruginous soil, irriguated but dried up at the moment. Some earlier maturing weedy types were sampled. They are awned and shatter easily. Represent locally a large proportion of rice plants in the field but it was seen only in a minority of the fields.

DR35 24/10 Poona to Belgaum
513 km from Bengalore
9 km before Belgaum
16°00N 74°30E 500-1000m

Pond at the deepest point of an irriguated rice field area. Ca 30-100 cm deep. Ferruginous soil on trap basalt.

Mixture of O. rufipogon and its hybrids with cultivars. Apparently perennial type. No rhizome could be observed on 5 plants digged out. Stems are branched with floating habit and adventicious roots.

Presence of Leersia hexandra attacked by a smut like disease. No pest nor parasite seen on wild rice.

Beginning of maturity.

DN36 25/10 3 km W of Belgaum on the way to Savantyadi
15°40N 74°30E 500-1000m

Smalll pond with a little outlet of water (probably used water from the city)

Ferruginous soil on trap basalt.

Annual type at the peak of its maturity.

Shattering only after the full maturity of the spikelets. Only on the fringe of the pond, mixed with Carex sp. Echinochloa sp. (?) and Panicum sp. No aerial plant in the deepest part but water weeds.

No rice field in the vicinity.

The pond is reputed to be perennial. It may be wondered why only an annual type of wild rice was found in it.

DR37 25/10 Belgaum to Goa
15°40N 74°20E 200-500m

Swampy area in a slum outside of Belgaum, between a bridge and a track. Ferrugineous soil on trap basalt.

Large population in deep water, partly grazed by cattle. Nearby a paddy field.

Typical perennial type, late maturing. It had just started flowering. No seeds.

2 plants were collected to be kept at CRRI in Cuttack for seed multiplication.

DR 38 25/10 Belgaum to Goa
5 km from Belgaum
15°35N 74°20E 200 to 500 m

Large pond (Ca 5000 m^2) on both sides of the road. Disturbed area. Nearby rice fields.

Perennial type, peak flowering, beginning of maturity. Almost pure stand of wild rice. Panicules are very much open. Seeds were colleted in only one pond.

DN39 24/10 Belgaum to Goa (Nal Hwy 4A)
31 km after Belgaum - Just before
Longa-Gangavali area.

Small pond on laterite. Shallow sandy soil. Forested area. Near a finger millet field.
Annual type. Complete maturity.

DN40 25/10 Pajani to Bombay, State highway
Village Sirsai Bardez
15°30N 73°50E < 100 m

Small population on the fringe of a large pond. This pond is said to be cultivated from time to time.
Annual type. Peak maturity.

DN41 26/10 Goa to Bombay. 77 Km after Goa, 1 km before Saligaou
16°00 N 73°40E < 100 m

Small pond on basalt.
Annual type mixed with Leersia hexandra.
Begining of maturity. Rice field nearby.

DN42 26/10 Goa to Bombay
121 Km after Goa 405 km before Panvel
16°20N 73°35E <100m

Depression along the road Ca 500 m^2. 2o to 50 cm water. Medium size population. Annual or intermediate type. Full maturity. Many brown spots on the leaves (Helminthosporium). Rice field nearby being harvested.

DN43 26/10 Goa to Bombay
411 km after Goa,118 km before Panvel
Village Vahoor. District Raighadh
18°20N 73°15E <100m

Large pond (Ca 2500 m^2) 50 to 100 cm deep. The deepest part is occupied by water hacynth (Eichhornia sp.) and water lilies.

Typical annual type with coarse spikelets and large stiff awns. Rice fields in the vicinity. Coming from Goa, 7 populations of O. rufipogon, annual type, were observed between the km 77 and 141 from Goa. only three of them were sampled (DN41, 42 and 43) due to lack of time.

Wild rice collection in Western India October 1984

Weight (g) of samples handed to IRRI to the attention of D^{r} T.T. CHANG.

DN1	4.6	DN24	6.8
DN2	7.6	DN25	5.3
DO3	1.7	DN26	7.5
DO4	4.4	DS27	21.5
DN5	3.7	DN28	4.6
DN6	5.4	DN29	2.0
DN7	1.2	DN30	3.6
DN8	12.0	DN31	4.6
DN9	22.1	DN32	8.6
DN10	5.9	DN33	18.3
DS11	6.7	DW34	11.1
DN12	8.1	DR35	13.1
DN13	19.9	DN36	12.0
DS14	17.6	DR37 (plant sample to be multiplied at CRRI, Cuttack)	
DS15	10.1		
DS16	19.5	DR38	2.0
DS17	47.0	DN39	3.4
DS18	29.5	DN40	4.9
DS19	20.0	DN41	2.1
DS20	17.9	DN42	10.7
DN21	11.7	DN43	5.7
DN22	15.4		
DN23	1.0		

N.B. Seeds treated by endosulfan + lindane + mercure + anthraquinone.