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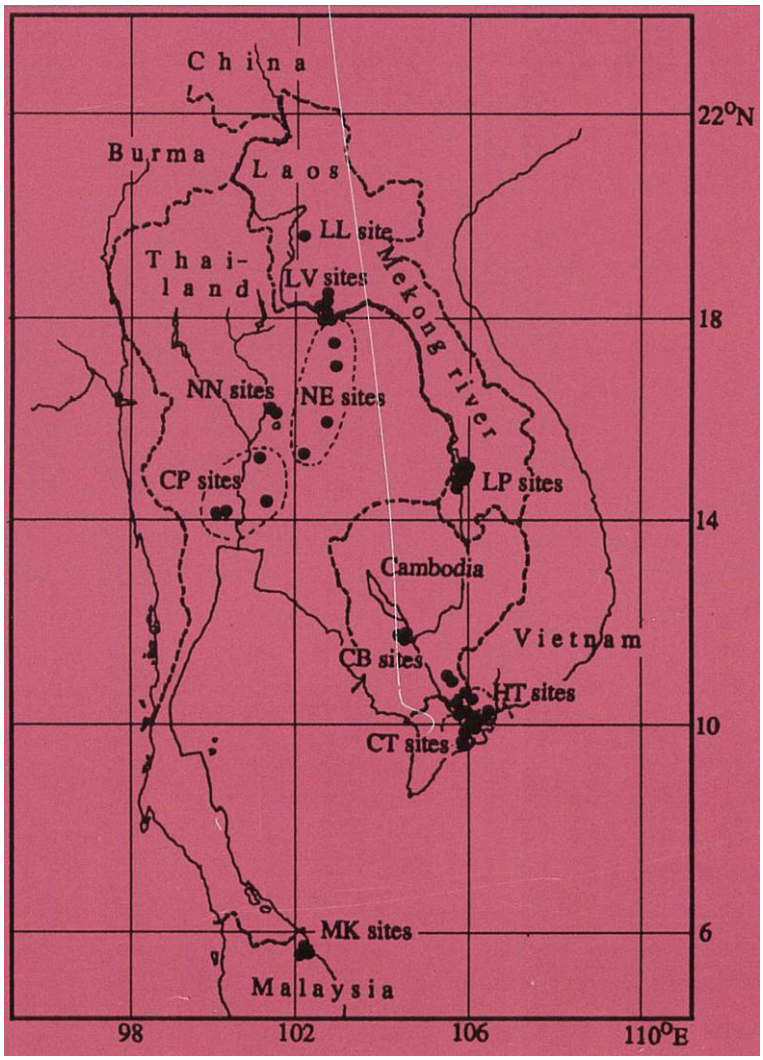
Ecological-Genetic Studies on Wild and Cultivated Rice in Tropical Asia (4th survey)

Edited by
Yo-Ichiro SATO



National Institute of Genetics
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[Cover] *Koompasia excelsa*, Kayu Rajah, the King of Malesian Rain Forest, Sabah, Borneo (M. Hotta).

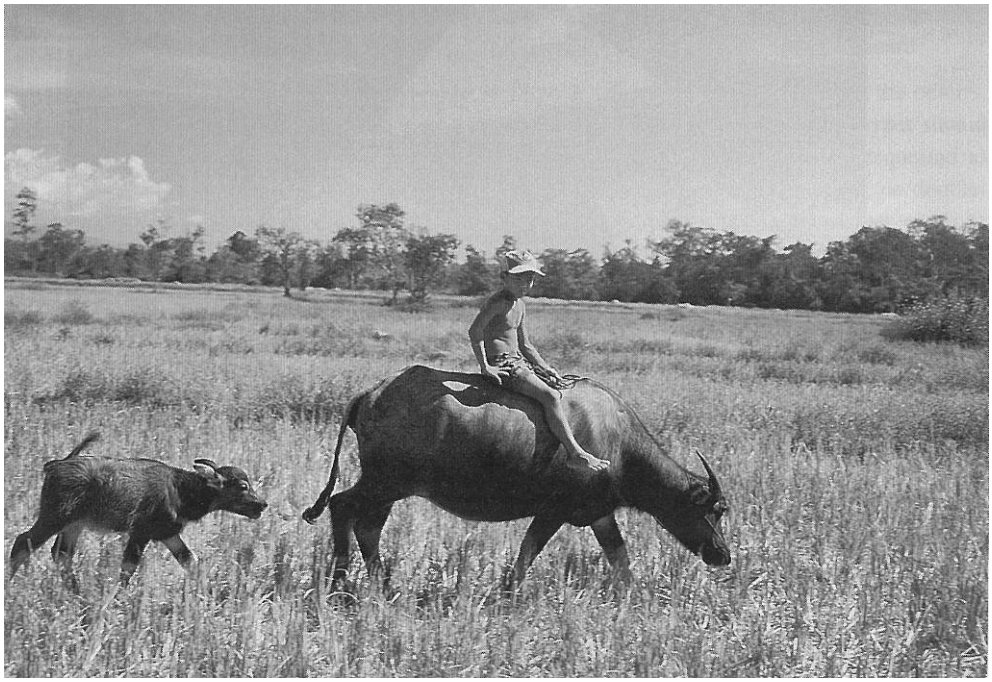
TROPICS Vol. 3 (3/4): 189-245 Issued March, 1994

Ecological-Genetic Studies on Wild and Cultivated Rice in Tropical Asia (4th survey)

by

Y. I. SATO (ed.),
K. ANDO, S. CHITRAKON, H. MORISHIMA, T. SATO,
Y. SHIMAMOTO, and H. YAMAGISHI

A young lady harvesting glutinous rice, at Vientiane. Photo by Y. I. Sato.



Upper: Back to the home, at Pakse. Photo taken by H. Yamagishi.
Lower: I am working now. Photo taken by T. Sato.

TROPICS 3 (3/4): 191-192 Issued March, 1994

Preface

Since early 1960's, Dr. H. I. Oka and his group in National Institute of Genetics have been studying wild rice and indigenous cultivars of cultivated rice to investigate their origin and phylogenetic relationship. They visited various places in different countries to observe ecological situation, and to get the seed samples for genetic studies. The studies by Dr. Oka and the team members have been published in many scientific journals, and their efforts have fruited as a book "Origin of cultivated rice" written by Dr. Oka in 1988.

The area that has been covered in Oka's period was rather limited. In the case of wild rice, a large "empty zone" at which limited number of materials had been collected lies to southeastern Asia. To survey wild and cultivated rice in this zone, the previous projects led by Dr. H. Morishima sent study-teames for Thailand (in 1983), for Indonesia (in 1985), and Bangladesh and Bhutan (in 1989). Yet, Indo-China area has been left empty, although it is an important area because the area lies between Indian and Chinese continents where are both centers of rice cultivation. To aim at observing wild and cultivated rice in Indo-China area, six scientists listed in page 193 visited various areas and made observations. Although our survey covered only a part of this area, I believe report of the study-tours is valuable for persons working on rice and on genetic resources.

Here, outline of each observation was described. Sites visited of wild rice through the project were summarized by Y.I. Sato. Detail for each tour is as follows.

In the first tour, observations were made in Laos and northeastern Thailand in November and December of 1991. In Laos, Yo-Ichiro Sato, Hiroko Morishima, Tadashi Sato and Hiroshi Yamagishi visited Luang Prabang, Vientiane and Phakse areas, and observed 20 populations of wild rice and 25 sites of indigenous cultivars. After the observation in Laos, they visited northeast Thailand (*isan*) across Mekong river at Thadua point, and traveled bound for Bangkok. Kazuo Ando joined after Udon Thani. In northeast Thailand, they visited the same sites that were observed in the previous trip in 1983 (cf. Morishima *et al.* 1984). A comparison was made between the records taken in 1983 and 1991 to evaluate the level of genetic erosion. H. Yamagishi described the outline of the tour and the records on wild rice in this trip. The records of cultivated rice were described by T. Sato. The level of genetic erosion in north and northeast Thailand was described by S. Chitrakon.

Second tour was made in February and March of 1992 for Malaysia, Thailand and Taiwan by Y. Shimamoto, T. Sato and Y.I. Sato. This time, natural populations of wild rice in east coastal area of Malay peninsula, near Kota Baru, were visited. In Thailand, observations for several populations that have been recurrently observed at every visit (permanent study-sites) were visited to take the records for the change on the biomass of wild rice. A brief report was made by Y. Shimamoto.

Third tour was made in December of 1992 for Vietnam and Cambodia. In Vietnam, areas of Mekong delta and Ho Chi Minh city were surveyed. The records of the observations for Mekong delta area were reported by H. Morishima. Y. I. Sato and T. Sato made trip up to Phnom Penh across the border to Cambodia. A rough sketch of the trip was described by Y. I. Sato. Taking the opportunities, permanent sites of wild rice populations near Bangkok city were visited again. A brief report for the present status of those permanent sites will be described by H. Morishima.

A supplemental trip for Laos was made in December of 1993 by Y. I. Sato and T. Sato.

The records were written by Y. I. Sato.

The appendix contains list of the observation sites, abstract from diary, list of persons and institutions to be acknowledged, and maps indicating the observation sites. Those were mostly debt to efforts of authors.

Yo-Ichiro SATO
National Institute of Genetics
Feb. 25, 1994

佐藤洋一郎(遺伝研)・**安藤和雄**(京大東南ア研)・ S. CHITRAKON (タイ・パトムタニ稲研究所)・**森島啓子**(遺伝研)・**佐藤雅志**(東北大遺生研)・**島本義也**(北大農)・**山岸博**(京都産大工)

熱帯アジア地域における野生および栽培稲の生態遺伝学的研究(第 4 次調査)

岡彦一博士以来続けられてきた稲の起源と伝播に関する研究のつづきとして，私たちはインドシナ半島における栽培および野生稲の調査を行った。インドシナ地域はインドと中国にはさまれ稲の起源の研究上重要な位置にありながら，政治的，経済的な問題によって今までに充分な調査ができなかった地域である。今回の調査によって明らかとなった結果を以下に述べる。

1)野生稲(*Oryza rufipogon*)の分布は Fig. 1-1 に示すようで，ラオスのビエンチャン付近，南部のパクセ付近，タイ東北部，カンボディア泉南部，ベトナムのメコンデルタ一帯に広く分布した。調査域にはまだ偏りがあり野生稲の分布の全容が明らかになったとは言えないが，*O. rufipogo*n はインドシナ半島にも広範に分布するとみられる。なおベトナム中北部の野生稲の分布の様相はまだ明らかにはされていない。

2)ラオスおよび東北タイで調査した野生稲の種および集団を Table 2-1 に示す。ラオス北部のルアンプラバンでは *O. rufipogon* はみられなかったが代わりに *O. granulata* の 1 集団をみることができた。この集団は Dr. Vaughan が 1991 年に調査したのと同じ集団である。ルアンプラバン付近では 1 年生型の野生稲の他，雑草稲と思われる集団もみられた。パクセ付近では道路脇の水路，溜池のふちなどに 1 年生のものと思われる野生稲が高い頻度で認められた。

3)ラオスでは陸稲を中心に栽培稲の在来品種の遺伝資源の調査も行った。北部では焼畑による陸稲栽培が残されているが中部と南部では天水田が広がっている。かんがい水田は例外的に認められるのみである。品種の圧倒的多数はモチ品種である。1 枚の畑の中の遺伝的多様度は高いようで，籾のサイズや形，色などに多型性が認められた。天水田の地帯では育種の事業もしだいに軌道に乗りつつあるが，全体としてはまだ在来品種のウェイトが大きい。

4)メコンデルタでは野生,栽培稲を調査した。野生稲は多年生型で *japonica* の遺伝子を持つ系統が多かった。かつては野生稲を利用した形跡が認められた。栽培稲の収量は，主に栽培法の「近代化」と品種改良によりここ数年急速に増加しつつあり，タイがベトナムを米輸出国としてのライバルとしてみているという報道を裏付けている。とくに IRRI の系統を直播きで栽培するなど新しい試みも行われている。

5)カンボディアでは主に野生稲を調査した。生態的環境がタイ東北部と似ていることもあり，1 年生型が多いなど稲の系統にも類似点が多かった。1 集団のサイズもタイのそれより大きいものが多いように思われた。また雑草型も 2 つのサイトで認められた。

6)今回の調査ではマレー半島北部の調査も行った。マレーシア側のコタバル付近で数系統の野生稲を調査した。

7)本調査は第 1 次調査から 10 年目にあたる。そこでタイ北部および東北部地域を対象にこの 10 年間の野生稲集団の消長を遺伝資源の喪失の実態調査の立場から検討した。調査した 21 集団のうち，バンコクに近い集団では集団のバイオマスが大幅に減少し，なかには絶滅した集団もあった。絶滅した集団の多くは道路の拡幅，工場用地としての埋め立てによってサイトそのものが破壊されたものである。また 1 年生の系統ではバイマスはこの 10 年足らずの間に平均で 15 パーセントにまで減少した。この減少率に変化がなければ，1 年生の集団は今世紀末までに絶滅の恐れがある。

8)また，この 10 年間にバンコク付近に設けた定点観測点での野生稲集団の盛衰に関する調査結果もとりまとめた。野生稲の集団は増減を繰り返しながらも全体としては現象傾向にある。付近には *O. rufipogon* ばかりでなく，*O. officinalis* や *O. minuta* など栽培稲とは比較的遠縁な数種の自然集団がみられる。こうした集団を遺伝資源と位置付けた *in situ* な保存も望まれる。

Contents

Members of the team

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Tadashi SATO, Institute for Genetic Ecology, Tohoku University, Aoba-ku, Sendai 980.
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Songkran CHITRAKON, Phatum Thani Rice Research Center, Phatum Thani, Thailand.
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Persons joined temporarily to study-tour(s)

Phoumy INTHAPANYA, Department of Agriculture & Extension, Ministry of Agr., Lao P. D.R.
Suvit PUCHIPAVESA, former expert, Lao-IRRI project.
Boriboon SOMRITH, Department of Agriculture, Thailand.

Trips

1. Laos and northeast Thailand, Dec. 2 - Dec. 20, 1991.
2. Thailand, Malaysia (peninsula) and Taiwan, Feb. 29 - Mar. 12, 1992.
3. Vietnam and Cambodia, Dec. 2 - Dec. 20, 1992.
4. Thailand, Mar. 15 - Mar. 20, 1993.
5. Laos and Thailand, Nov. 27 - Dec. 7, 1993.

Invitations

1. Mr. Phoumy INTHAPANYA, Mar. 15 - Mar. 21, 1993.
2. Dr. Boriboon SOMRITH, Nov. 20 - Nov.27, 1993.

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1. Geographical Distribution of the Natural Populations of *Oryza rufipogon* in Asia

Yo-Ichiro SATO (National Institute of Genetics, 1111 Yata, Mishima 411, Japan)

Geographical distribution of wild rice (*Oryza rufipogon*) has been surveyed frequently by botanists. Harlan (1975), and more recently Oka (1988) summarized records by various authors. After Oka (1988), Morishima et al. (1991) and Vaughan (1990, 1991) described new natural populations of wild rice in some countries. In the present project, we observed natural populations of wild rice in Indo-China countries. Here I attempt to arrange the present and the previous records to sketch the geographical distribution of wild rice in southeast Asia.

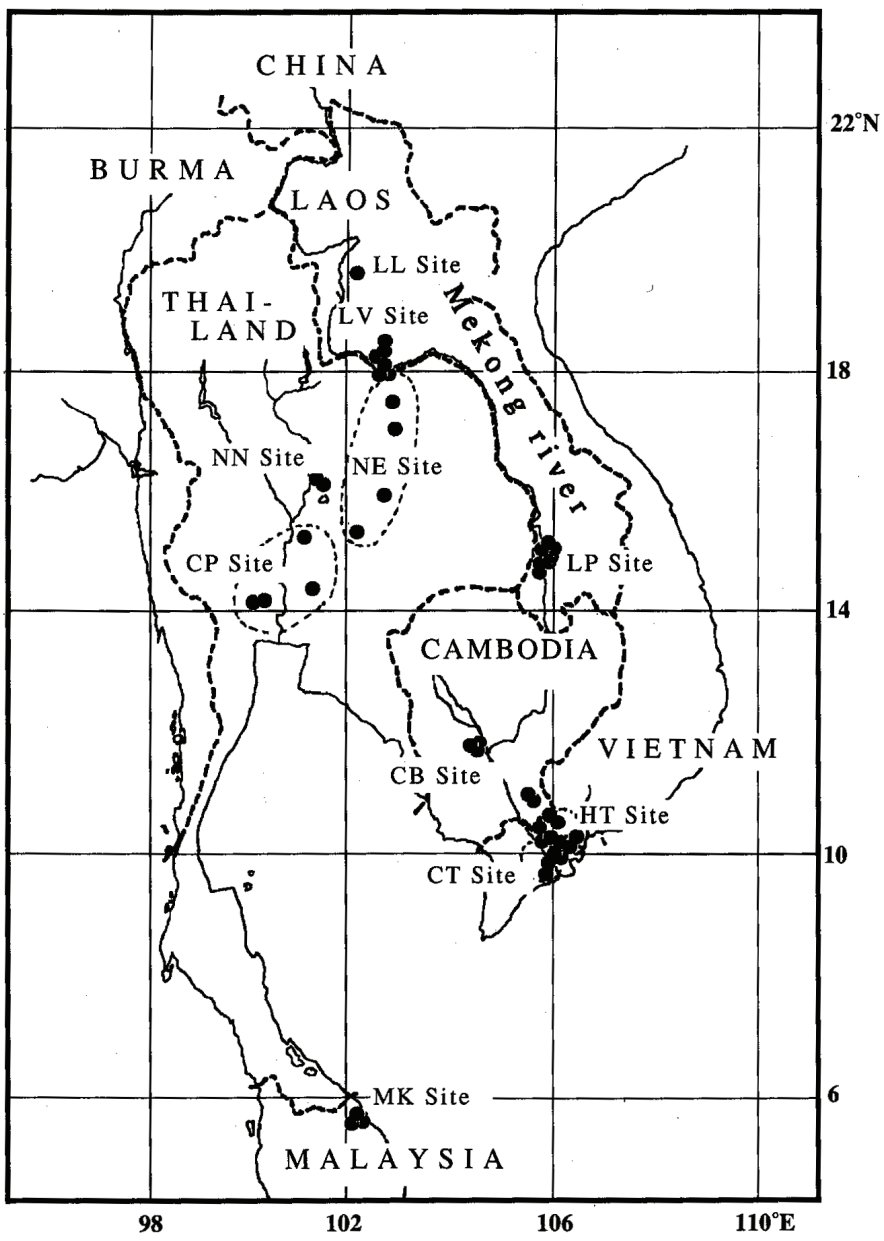

Fig. 1-1. A map of collection sites in Laos, Cambodia, Vietnam, Thailand and Malaysia.

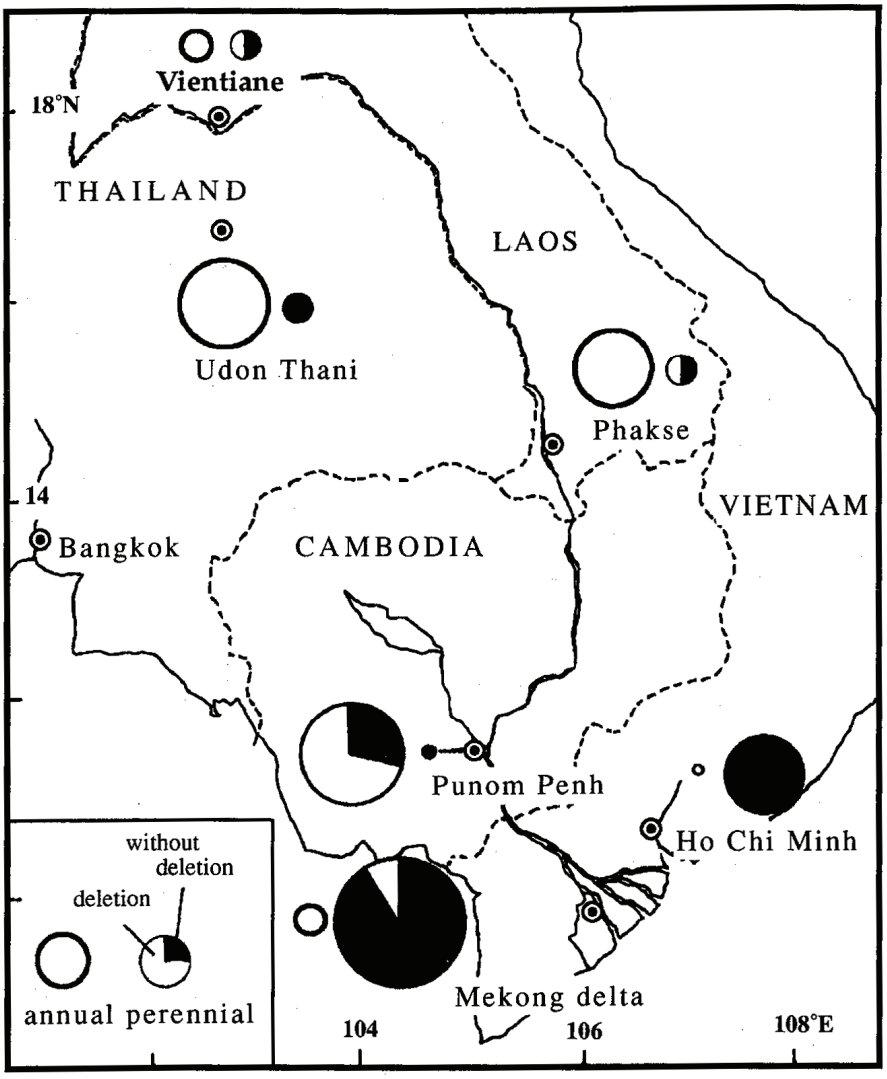

Fig. 1-2. Geographical distribution of perennial and annual types in Indochina area.

Method of the Record

We traveled Laos, Cambodia, Vietnam, Thailand and Malaysia during 1991-1993. When a natural population was discovered, we recorded the position, habitat condition, wild rice area, rice plant cover, companion plant species and circumstances. The position of the site was recorded by the global positioning system (GPS, Sony IPS360). This system represents the latitude and longitude by using signals from satellites within a few minutes. Error of measuring is within 50 meters.

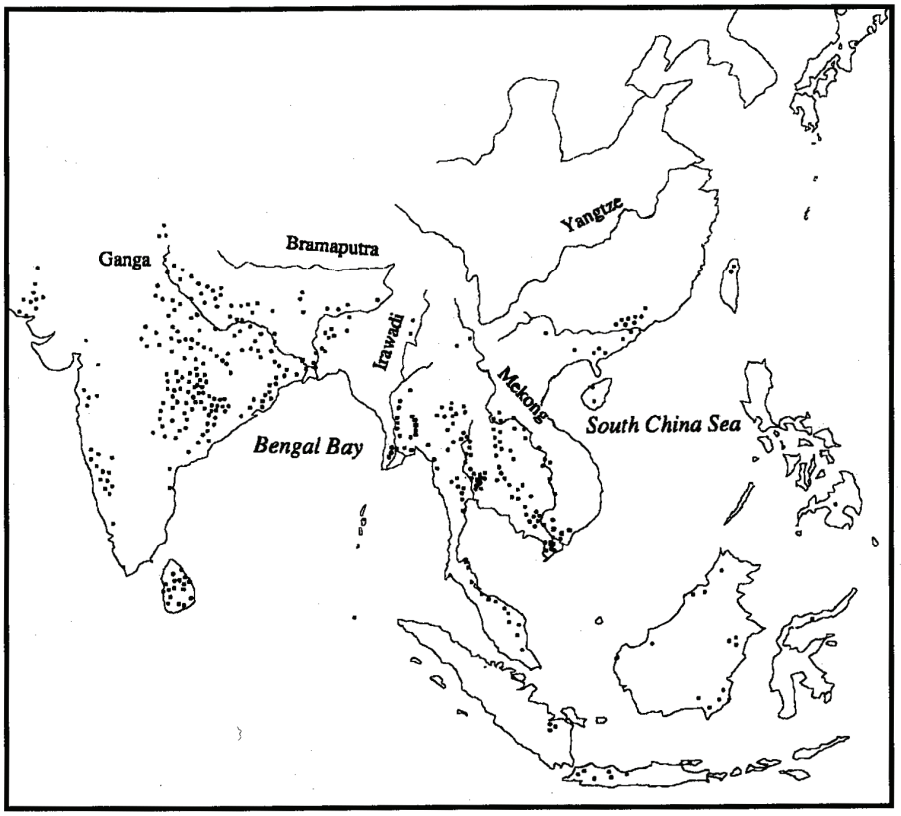

Fig. 1-3. Geographical distribution of natural population of *Oryza rufipogon* in southeast and south Asia.

Results and Discussion

Fig. 1-1 shows geographical distribution of natural populations of *O. rufipogon* visited during 1991-1993. In 1991, we visited Laos and northeast Thailand. In this trip, eight populations near Vientiane and seven populations near Phakse were visited. At Luang Prabang area, we visited one site of *O. granulata* but no ones of *O. rufipogon*. This *granulata* site was the same one as Dr. Vaughan has visited in the past. But those near Phakse appear in scientific report first. Six new populations were also visited in northeast Thailand. In December of 1993, three populations near Vientiane were newly observed. In the trip of winter of 1992, we visited Vietnam and Cambodia. We observed ten populations in Mekong delta, eight ones near Ho Chi Minh city, four ones in-between Ho Chi Minh and Phnom Penh, and five ones inside Phnum Penh city. After coming back from Vietnam, nine new populations were visited in north and central plain of Thailand. Seven populations were recorded in east seacoast of Malaysia in the spring of 1992. Afterall, 67 populations were observed during the present project.

Number of strains collected exceeded 200. The seeds of those strains were multiplied at Mishima in 1992 and 1993. They will be provided to any scientists upon the request.

Strains of *O. rufipogon* are divided into annual, perennial and their intermediate types (Oka 1988). Fig. 1-2 shows geographical distribution of annual and perennial (including intermediate) types of *O. rufipogon* in Indo-China peninsula. Annual types are sometimes described as *O. nivara*, or previously, as *O. sativa* var. *spontanea*. The annual and perennial types tend to have *indica* and *japonica* features, respectively, with

regard to nuclear and cytoplasmic genomes. Strains of annual type having *indica*-type genomes were distributed in an area from northeast Thailand to the middle basin of Mekong river, while those of perennial type were in southern coastal areas or lower basin of Mekong river.

Fig. 1-3 shows natural populations of *O. rufipogon*, which were compiled by Harlan (1975) and Oka (1988). Those found by Vaughan (1990, 1991) and Morishima *et al.* (1991) were also included in the figure. Populations visited by our team were also added. The natural populations of *O. rufipogon* were distributed all over the tropical Asia except for Burma and north Vietnam. In these two regions, records of *O. rufipogon* have been limited due to insufficient chance of observations. Systematic observations for these regions in future are preferable to illustrate the pattern of *O. rufipogon* in the tropical Asia.

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2. Wild Rice in the Middle Basin of Mekong River

Hiroshi YAMAGISHI
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We made the trip in Laos from December 5 to 13, 1991, and afterwards, crossing Mekong river, traveled northeast region of Thailand. In those areas we observed the populations of wild rice and collected the seeds, with the following major purposes.

1) Wild rice species and their distribution in Laos were poorly known, only one systematic observation being made by Vaughan (1990). He covered mainly Vientiane plain and Luang Prabang valley, and observed the distribution of *Oryza rufipogon* in the former while *O. granulata* in the latter. In order to obtain more information on the distribution and characteristics of the wild rice, we traveled three regions, *i. e.*, Luang Prabang, Pakse and Vientiane.

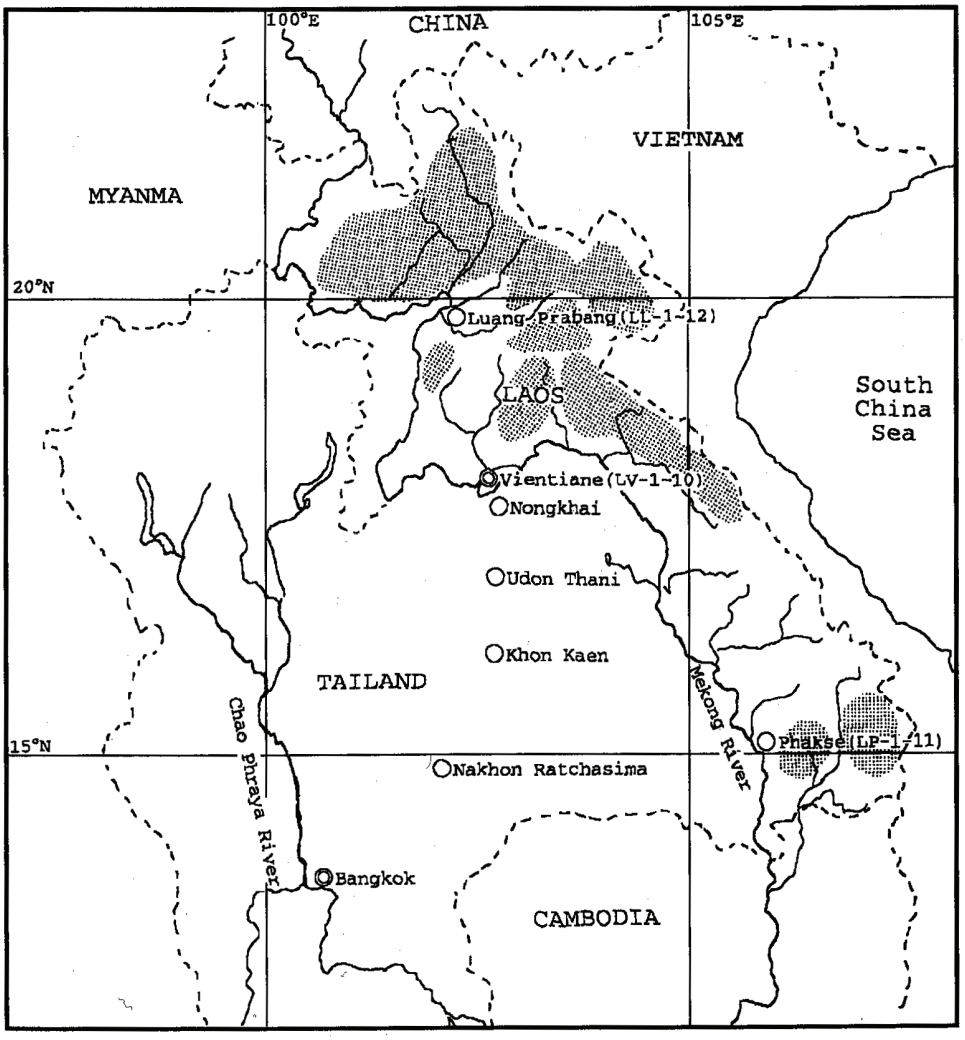

Fig. 2-1. Observation and collection areas of wild rice in Laos and northeast Thailand.

2) In 1983 we made an observation and collection tour in Thailand, including the northeast region. We tried to observe what changes have occurred in the wild rice populations during is eight years.

In this report, mainly the results of observation in Laos are mentioned, and the changes in the populations of Thailand are described in detail by S. Chitrakon (p. 223).

Outline of the Observation of Wild Rice

Our travel areas are shown in Fig. 2-1. Those are divided into four parts as summarized bellow. In addition to the observations of wild rice populations, we collected the seeds of them in the sites where they matured. The collection sites and collected species in these areas are presented in Table 2-1.

1. Luang Prabang (LL1～12)

Luang Prabang is an old city in the valley of northern part of Laos. In the area the cultivated rice had been already harvested. Although we visited eleven sites in the area, including the paddy fields near Mekong river and mountainous shifting field, we could not find the populations of *O. rufipogon* or *O. officinalis*. Only one collection was from a small population of *O. granulata* in the forest near the shifting field of Ban Laksip village (Fig.2-2), which Dr. Vaughan had found in 1990.

2. Phakse (LP1～11)

Phakse places in the plain along Mekong in the southern part of Laos. We made the observation around the town of Phakse and on the way to Wat Phu, which is a ruin on the western side of Mekong. Most of the cultivated rice had been harvested and the paddy field were dried up. Wild rice, all of which are *O. rufipogon*, were distributed widely, in the dry roadside ditch, on the fringe of shallow swamps and in the ponds.

3. Vientiane (LV1～10)

We observed the wild rice in the suburbs of Vientiane and on the way to ferry port connecting to Nongkhai, Thailand. The wild rice plants grew abundantly, mainly in paddy side ditch and road side ponds, but the populations were not so large as those in Phakse. They were estimated as *O. rufipogon*. In a site (LV9), we observed the possibility that the wild rice had reproductive contacts with the cultivar in the paddy field.

Table 2-1. Wild rice collection in Laos and northeast Thailand.

Areas	Species	No. of samples	No. of sites
Luang Prabang	*O. granulata*	1	1
Phakse	*O. rufipogon*	18	9
Vientiane	*O. rufipogon*	6	5
	Mixture of wild and cultivated rice	3	1
	Not identified	2	1
Northeast Thailand	*O. rufipogon*	3	3
	Not identified	21	8

Fig. 2-2. Shifting field in a mountainous area of Luang Prabang.

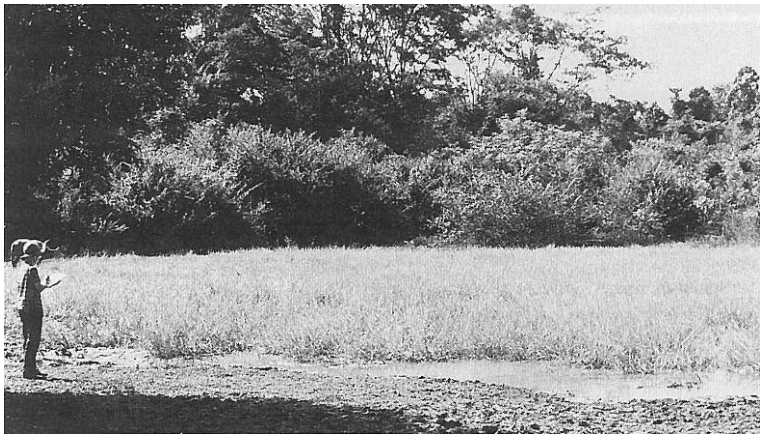

Fig. 2-3. A huge population of *O. rufipogon* (LP7).

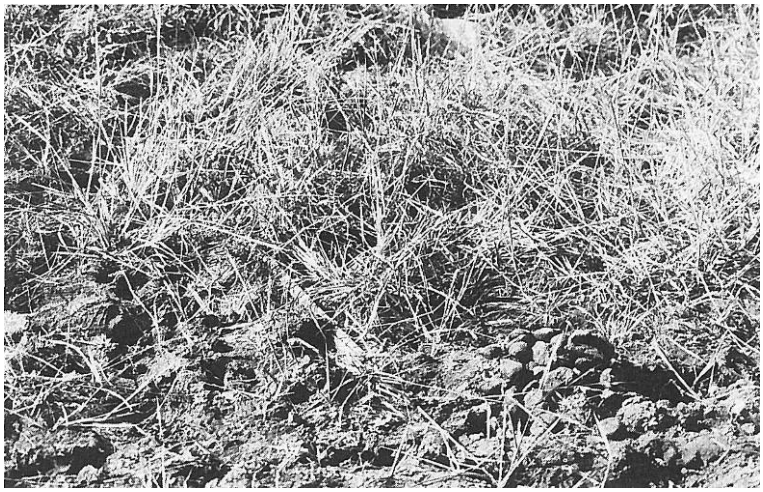

Fig. 2-4. Disturbance of a wild rice population by animals (LP5).

4. Northeast Thailand (NE35～99)

In Thailand we traveled from Nongkhai to Bangkok through Udon Thani, Khon Kean and Nakhon Ratchasima. We tried to stop at the sites where the wild rice populations were recorded in 1983. But we could not find several ones, because of disappearment of the populations by the changes of land utilization or pollution of water. On the other hand, seed collections were made at nine sites which we did not visit in 1983.

Fig. 2-5, 6 Ponds in Wat Phu, and wild population growing in one of them (LP 10).

Fig. 2-7. Observation of the seeds having the characteristics of hybrids between wild and cultivated rice.

Wild rice collected in Laos and northeast Thailand.

Table 2-1 shows the species, number of samples and collection sites, summarized from Appendix 4. The seeds were collected by bulk method or from respective panicles.

The collected seeds were stocked in National Institute of Genetics, and used for morphological and ecological investigations. The variations among and within the

populations would be clarified by those studies. Some of the seeds are under multiplication.

Extracts from Field Notes

1. Phakse

We observed large size populations in several places. They were road side dried ditches and natural or artificial ponds. Most of the populations were estimated to be annual type of *O. rufipogon* by the morphological observations and ecological characteristics informed by the farmers. Fig. 2-3 shows an example of the huge populations (LP7) growing in the pond, the diameter of which was more than 300 m. The wild rice was distributed in the shallow part of the pond, and the deeper part was taken place by sedge. The populations in the dry area were severely disturbed by cows as an example shown in Fig. 2-4 (LP5). At the fringe of the deep ponds in Wat Phu (Fig. 2-5, 2-6, LP10), wild rice in flowering stage was observed.

2. Vientiane

Most of the wild populations were annual type of *O. rufipogon*, though that of LV1 had perennial like characteristics, namely the plants were late to flower and had long anthers. In LV9, the site near to Mekong river, where the maximum water level goes up to 1-1.5 m, the seeds of different characteristics from cultivars were found in the edge of paddy field. Because the plants had been harvested already, we could not observe the plants. However, we collected the seeds as it was considered that the presence of such seeds would suggest the hybridization between wild and cultivated rice (Fig. 2-7).

3. Northeast Thailand

Beside the previously visited sites, we observed several new ones. In Appendix 4, site numbers smaller than ninety indicate the same ones with those observed in 1983, though the numbers with the prime mean that the sites are near to the previous ones. Site numbers larger than ninety show the new ones. Among them, NE96 in a basin placing between railway and Route No. 2 was a large scale pure population of *O. rufipogon*. The plant height in dry area was about 100 cm, and they had long panicles with the seeds of good fertility.

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3. Observations on Cultivated Rice in Laos

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From 5 December to 13 December, we traveled in Laos. The trip covered Luang Prabang valley, Phakse plain and Vientiane plain.

Rice is the important crop in Laos. Total rice production in Laos averages 1.5 million tons/year for the past ten years. In 1990, the area cultivated with rice represented more than 80% of the cropped land area. The cultivated rice area of Laos comprised 60% rainfed lowland, 39% rainfed upland and less than 2% irrigated paddy field (Table 3-1). The wet season (rainfed lowland rice), the rainfed upland rice and the dry-season irrigated rice production accounted for 72%, 25% and 3% of total rice production, respectively. Yield of the rainfed lowland, rainfed upland and irrigated lowland area officially recorded 2.75, 1.46 and 3.43 tons/ha, respectively.

The area of rainfed upland rice was greater in the province of Luang Prabang, where rice varieties being grown were local varieties. The average yield of the upland rice was obviously lower than the wet-season lowland and irrigated rice. In the province of Vientiane M. and Champasak, the rainfed lowland rice cultivation predominate. The irrigated lowland rice production in the province of Vientiane M. accounts for approximately 12% of area and 15% of production.

Table 3-1. Harvested area, production and yield of rice in the Province of Luang Prabang(LPR), Vientiane M.(VTE) an Champasak (CMS).

		Lao PDR	LPR	VTE	CMS
Rainfed lowland rice	Area (ha)	396,476	6,498	41,607	74,455
		(64%)	(9%)	(86%)	(93%)
	Production (t)	1,088,477	25,494	135,025	171,247
		(72%)	(23%)	(84%)	(93%)
	Yield (t/ha)	2.75	3.00	3.25	2.30
Irrigated rice	Area	11,392	848	6,368	440
		(2%)	(1%)	(12%)	(1%)
	Production	39,101	2,500	24,091	1,575
		(3%)	(2%)	(15%)	(1%)
	Yield	3.43	2.95	3.78	3.58
Rainfed upland rice	Area	260,178	63,000	640	5,540
		(39%)	(88%)	(2%)	(1%)
	Production	380,948	83,425	783	11,047
		(25%)	(75%)	(1%)	(6%)
Total	Area	656,654	71,498	42,247	79,995
	Production	1,508,402	111,419	159,899	183,869
	Yield	2.30	1.56	3.78	2.30

Data based on basic statistics about the socio-economic development in the Lao PDR for 15 years (1975-1990)

In order to investigate the characteristics of rice fields and rice plants, we made a trip in Luang Prabang valley, Phakse plain and Vientiane plain. Information of cropping system, cultural methods and other problems were obtained from local officials and farmer representatives. Extract from field notes and a brief account of some characteristics of rice seeds collected are given below. The characteristics of the fields and rice plants in each individual site and accession were shown in appendix 4.

Luang Prabang

During December 6 to December 8, we observed cultivated rice fields at 12 sites and collected 34 accessions of local rice varieties. Luang Prabang valley is surrounded by mountains less than 2,000 meter altitude. Rainfed lowland rice was grown in terraced paddy fields on hillside and valley floors (Fig. 3-1). Rainfed upland rice was grown on both flat and sloping fields (slash and burn) that were not banded (Fig. 3-2). When we traveled in early December, most of rice plants were already harvested. This area is located in the monsoon belt and has a subtropical climate with two distinct seasons. Rainfall averages about 1,300 mm/year and is distributed in a monsoon pattern, with more than 80% falling in the six month period from May to October. In this area, rice seedling is transplanting usually in July and harvesting in November-October. Timing of rice cultivation is determined by rainfall distribution.

Rice cultivars grown in this area were more largely glutinous and traditional ones. The grain shape of rice seeds collected seemed large and its length was longer than 8 mm. Almost all rice cultivars grown in upland fields were glabrous and belonged to japonica. The officially recorded lowland rice field in 1990 averaged 3.0 tons/ha. Actual average yield is believed to be below this record. In fact, we were told the yield of rainfed lowland rice was 0.8 to 1.5 tons/ha. The soil in terraced fields were characterized as having low fertility and slightly acidic (pH 5.8-6.4).

Fig. 3-1. Terraced lowland fields in Luang Prabang valley.

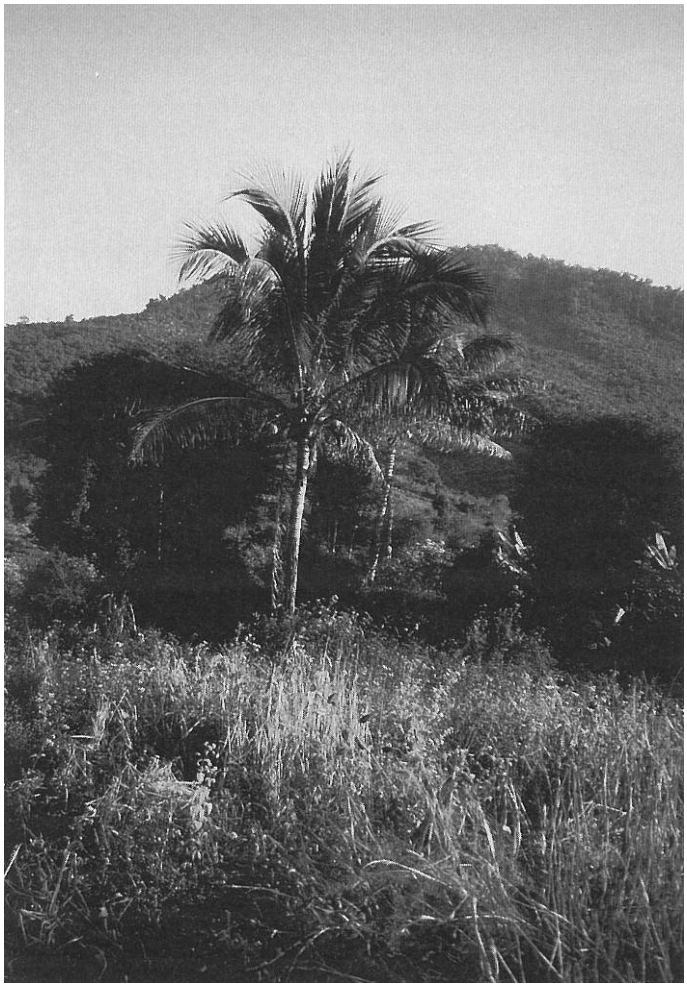

Fig. 3-2. Slash-and-burn upland field on the hillside in Luang Prabang valley.

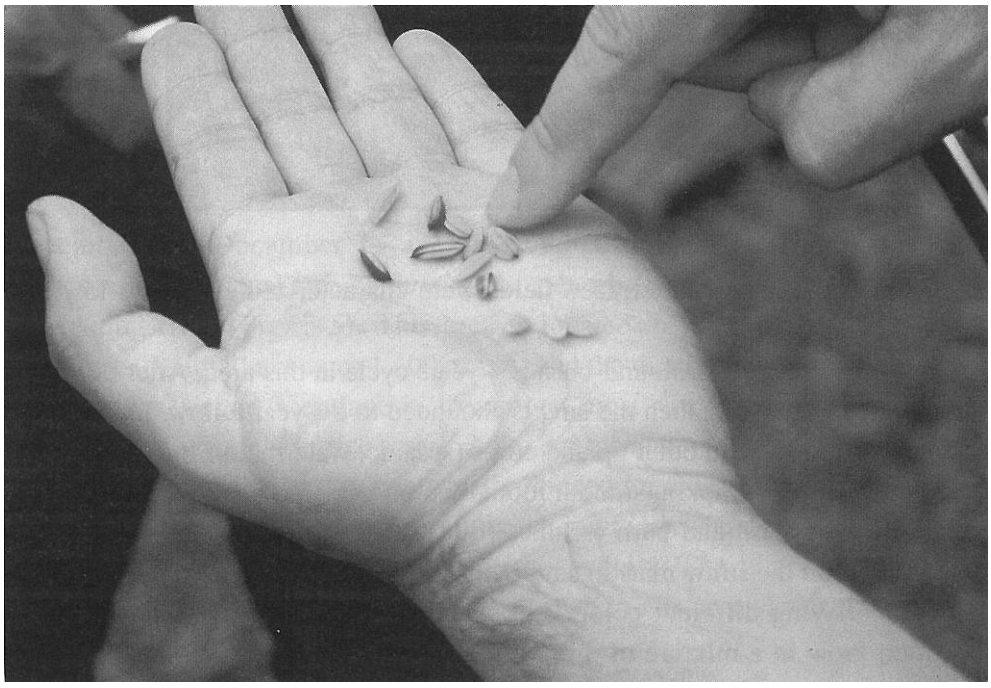

Fig. 3-3. Upland rice seeds dried on rice straw mat in Luang Prabang valley.

Fig. 3-4. Harvest of rainfed lowland rice in Phakse plain.

Fig. 3-5. Rainfed lowland fields in Vientiane plain.

This shifting system of slash-and-burn is 4 years cycle in this area. After burning the trees, rice is cultivated at 1st year; then the land is abounded to a 3 year fallow. In this shifting field, upland rice was grown with other upland crops (sesame, watermelon, wax ground, cucumber, native melon, squash, pumpkin, smooth loofah lemon grass and egg plant) on newly opened land cleared by the slash-and-burn technics (Site LL6). Rice seeds harvested in the shifting fields were dried on the straw mats in small village "Lak Sip" (Site LL5). These rice included various grains having different colors and shapes (Fig. 3-3). We were told that mountain farmers often grow in a mixture of 3 or 4 rice

varieties with different maturity times in the upland field, because of evading the decrease of rice production by climactic variability. The sandy loam soils prevailed in the upland areas and also generally infertile and poor water holding capacity. According to officers of agricultural experimental station, slash-and-burn cultivation is a serious impediment to rational forest management and sustainable use of soil and water.

Phakse

During December 9 - December 10, we observed cultivated rice fields at 6 sites and collected 13 accessions of local rice cultivars. The area observed in and around Phakse (the capital city of Champasak province) is flat land at an altitude of less than 300 m. This area is located in the monsoon belt and has a tropical climate. Rainfall averages about 1,450 mm/year and is distributed in a monsoon pattern, with more than 70% falling in the four month period from July to October. When we visited Phakse in December, the rice fields were dried. Most of rice cultivars collected in this area were glutinous and seemed to belong indica.

Except for LP6, the rice fields observed were rainfed lowland ones. In rainfed lowland rice fields, most often transplanting takes place from late June to early July. When we visited in this area, we saw that farmers were harvesting rice plant (Fig. 3-4). Harvesting time of rice in this year was later than an average year. Furthermore, the yield of this year is half of usual year's yield (2.5 tons/ha), because of a big flood. In the adjacent lower rice fields, rice plants mostly died due to flood. We were told that the rice yield of rainfed lowland and upland cultivation often decreased in years of severe drought. With the majority of rice grown under rainfed lowland fields, production is very sustainable to climactic viability. Individual lowland rice farmers cultivated 3-4 rice cultivars. We saw not only local rice cultivars but improved rice cultivars (RD8, RD10) of Thailand and Vietnam. According to farmers, these improved rice cultivars are high yield ones. The rice field soils in this area were mainly reddish-brown laterites and acid in the surface of soil (pH 4.6-5.3).

In the upland system, the main food crop, rice is cultivated for 3 years; then the land is aboundoned to a 3 year fallow. We saw that, in upland field (Site LP6), a number of crops and trees were grown in mixture; chilly, egg plant, corn, squash, bamboo, mimosa, legume and tiger small.

Vientiane

During December 11 - December 13, we observed cultivated rice fields at 4 sites and collected 7 accessions of local rice cultivars. The area observed in and around Vientiane is flat along Mekong river (Fig. 3-5). This area is located in the monsoon belt and has a subtropical climate. Rainfall averages 1,600 m/year and the distribution of rainfall is the same as Phakse. When we visited Vientiane in December, most rice plants were harvested. We were told that the average yield of rice area is 2.5 to 3.5 tons/ha.

Rainfed lowland rice fields in this area usually flooded for at least part of cropping season at water depths that exceed one meter. Therefore, the rainfed-lowland rice cultivars grown in this area seems to have the internode elongation capacity. The improved rice cultivars introduced from Thailand and Vietnam were also grown in this area. The cultivation area of traditional rice cultivars in Vientiane is rapidly decreasing.

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4. Rice in the Mekong Delta

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In the middle of December 1992, we made a short study-trip in the Mekong Delta. Our trip covered deepwater area in Dong Thap Province (a), backswamp in Can Tho and Vinh Long Provinces (b), and route between Can Tho and Hochi Minh, and the suburb of Hochi Minh (see Appendix 2-2). Trip (a) was kindly guided by Mr. H.Q. Tin, trip (b) by Mr. V.D. Tri and Mr. H.Q. Tin, and trip (c) partly by Mr. N.N. De. Some extracts from our field notes are given below. We could learn many things from plants and people, though our observations were too sketchy to cover whole Mekong Delta.

Wild Rice

In Vietnam, three wild rice species are reported to date, *O. rufipogon*, *O. meyeriana* and *O. officinalis*. Dr. D. Vaughan collected the former two species in North Vietnam (Vaughan 1989). *O. officinalis* is known only in herbarium. Wild rice populations we observed during the present trip in South Vietnam were all *O. rufipogon*. In 19 sites, we made observations on habitat conditions and seed sampling.

(A) Plant characters and habitats

Most of the wild-rice populations were growing in and at the fringe of irrigation canal or roadside ditch. Sustained water depth at those sites varied from 0 (wet) to about 1 m at the time of our visit. In tidal area, difference between the highest and lowest level of canal water in a day is 1.0 - 1.5 m. Wild-rice plants had 1 - 3 m plant height, 4-5 mm anther length and relatively long panicles. Their growth stage was from flowering to seed maturity. Judging from their morphology and habitat conditions, wild rice we saw were all perennial type of *O. rufipogon*.

In deepwater area (Tam Nong District, Dong Thap Prov.), we were told that 20 years ago wild rices were growing in 20,000 ha but at present it reduced to 400 ha. Four populations we observed in this area seemed to differ slightly from other populations distributed outside the deepwater area. Tam Nong populations had good seed fertility and high proportion of reproductive tillers (tillers with panicle) to vegetative tillers. In other populations, however, seed setting was not always high (30 - 50 %), and only a few out of many tillers produced panicles. Moreover, under a weak short-day treatment in Mishima, two out of four populations collected in Tam Nong flowered in middle September, while none of 25 populations collected in other areas initiated panicles, indicating that photoperiodic sensitivity of Tam Nong populations was weaker than others. The above observations suggest that Tam Nong populations have higher seed productivity and earlier flowering time than others, in other words they tend to show annual habit. It should be noted that those Tam Nong populations were found along the irrigation canal which was recently constructed. In contrast, populations outside this deepwater area were at the fringe of roadside ditch in which they had been established since long before. It can be supposed that Tam Nong populations are those which survived strong habitat disturbance at the time of canal construction and colonized to new habitats with their high seed propagating ability.

To what extent wild rice populations are exchanging genes with cultivated rice growing nearby is one of the interesting problems. Many of the wild rice populations we observed were distributed near the cultivated rice fields. Yet, we could not detect a trace of introgression in those populations, except for a few cases in the suburb of Ho Chi Minh city. In Tam Nong district, the land had been cleared for the coming dry season planting when we visited. Therefore, we could not know how wild and cultivated rices were interacting in wet season in this deepwater area. It is not known whether or not high seed productivity carried by wild rices growing along irrigation canal in this area as mentioned above was brought about by gene flow from cultivars which might have occurred in the past.

(B) Wild rice and human life

During our trip, we frequently heard that local people are used to utilize wild rice for various purposes. Wild-rice plants growing in roadside ditch are cut once or twice a year. At HT14, we were told they cut wild rice to give it to fishes. At CT5 in a huge swampy area in Tam Nong, we saw wild-rice plants growing in 100 × 50 m area had been cut at the height of 30 cm above the ground and were being dried on the adjacent canal bank. In these cut plants, no seeds were left on the panicles (artificially collected or naturally shed?). They said those dried plants are used to cover soil surface of vegetable (eschallot) field. These wild-rices seemed to have relatively short many panicles, suggesting that they are not typical perennial type. According to local people, this swampy area was formerly planted to floating rice, but abandoned since 1978 because water was too deep.

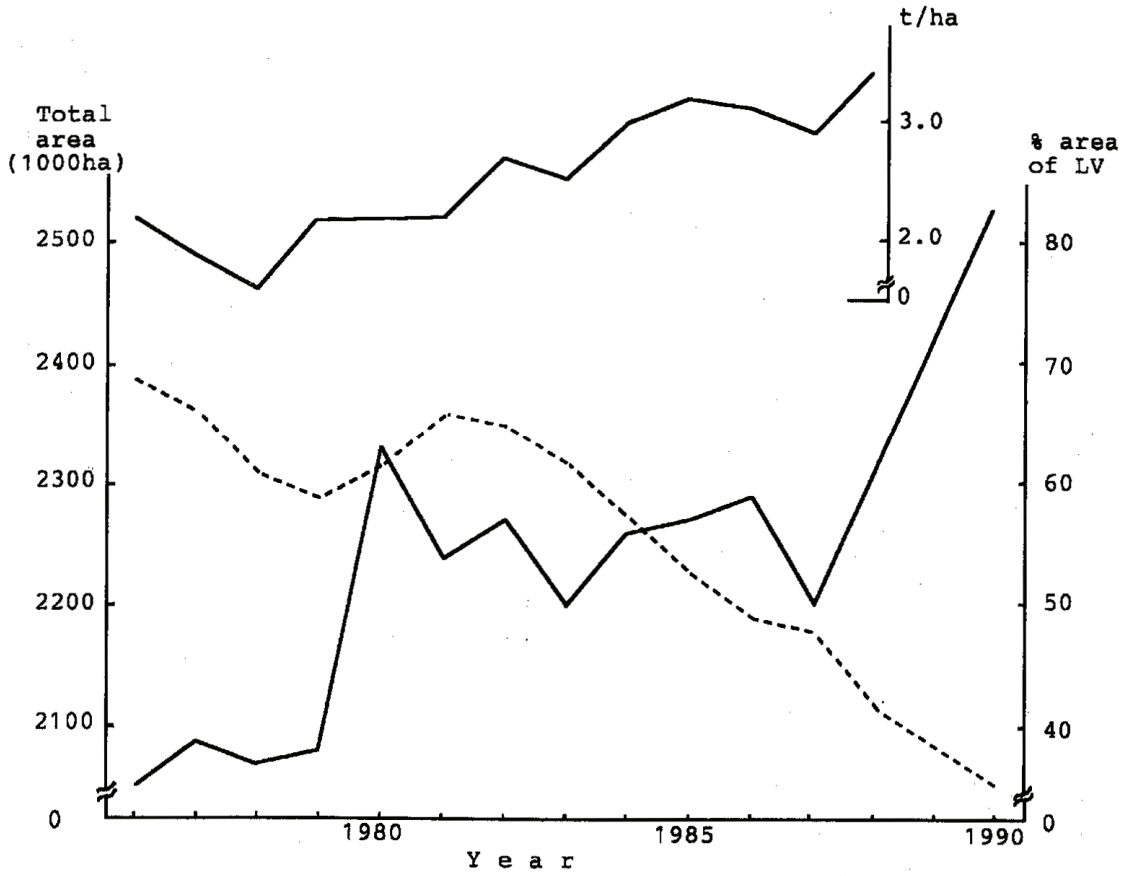

Fig. 4-1. Total rice area and proportion of local variety (LV) area in the Mekong Delta (Source: Agricultural Office of Hau Giang Province).

Table 4-1. Total rice cultivated area (ha) in the Mekong delta in 1990.

Provinces	Total area	Area of HYV[1)]	area of LV[2)]	% area of LV
Long An	325,000	195,000	130,000	40
Tien Giang	105,860	88,347	17,513	17
Dong Thap	276,383	263,186	13,197	5
Ben Tre	105,000	55,000	50,000	48
Cuu Long	309,730	217,714	92,016	30
Hau Giang	479,694	261,109	218,585	46
An Giang	320,490	287,490	33,000	10
Kieng Giang	309,449	144,150	165,299	53
Minh Hai	296,600	135,000	160,600	54
Total	2,528,206	1,647,996	880,210	35

1) HYV: High yielding variety
2): LV: Local variety

At two places, we heard that seeds of wild rice were harvested for foods. Harvesting of wild-rice seeds in Tam Nong District was as follows. Two persons go into a wild rice site by a small boat, and knock the panicles by a stick to let the seeds drop in their boat. Seeds are put in a cloth bag and soaked in water for a couple of days to soften awns, sundried until the grains become hard, and milled. Grains are cooked in the same manner as the ordinary rice. Since wild rice matures one month earlier than cultivated rice, they eat wild rice mainly to meet the shortage of food. Forty to sixty kilogram (max. 100 kg) can be collected in a day. An old man at CT13 remembered that his father living in deepwater area had ate wild rice when the crops failed. It was said that collection of wild rice seeds should be done in the early morning.

Cultivated Rice

In the present trip we were strongly impressed that high yielding varieties (HYV) are successfully cultivated particularly by broadcasting method in the Mekong Delta. This was made possible by the development of irrigation and drainage system which markedly changed agricultural situation in the Mekong Delta. Fig. 4-1 shows the increase of rice area and decrease of relative proportion of area planted to local varieties during last 20 years. As shown in Table 4-1, relative proportions of HYV and local varieties greatly differ among provinces. In Dong Thap and An Giang, local varieties were almost replaced by HYV. Collection and conservation of local varieties are extensively carried out by the staff of Gene Bank, Mekong Delta Farming Systems and R & D Center in Can Tho University.

(A) Deepwater area

There is a huge inland delta area along the upper basins of the Mekong River and the Bassack River. Until 1977, this area was deeply inundated during the wet season, and only floating rice varieties could be cultivated once a year. We visited Agricultural Technology Center at Cao Lanh (capital of the Dong Thap Province) and learned general situation in this deepwater area from Mr. N.P. Tuyen (Head of the Center). Formerly single cropping of floating rice (July - December) had been practiced in deepwater (3 m at maximum). Now double cropping (November - March in dry season, April - August in wet season) is commonly carried out using HYV. Major varieties used are; MTL58 (40%), IR64 (20%), IR35546 (15%), IR50401, IR50404, MTL 99, etc. Area planted to glutinous

varieties is only 2% in Don Thap Province. We traveled by a motor boat along the canal in Tam Nong District near Cambodian border. By construction of irrigation canal, the arable land in this area was much expanded and dry season crop was made possible.

We talked with a promising farmer Mr. Sau (67 years old) who moved to this village (Phu Cuong) several years ago. He owned 30 ha. An improved variety MTL 103 is used both in wet (Apr - Aug) and dry season crops (Dec - Mar). Using a hand tractor and carabao, land is cultivated. Two-hundred kg of ammonium phosphate and 150 kg urea are applied per ha. He gets 5 t/ha in dry season and 3.5-4 t/ha in wet season, although floating rice he cultivated before yielded only 1.1 - 1.6 ton/ha. At the time of our visit, the land was mostly cleared for dry season planting, but in part broadcasted floating rices were still present at the stage of seed maturity (CT2). In the southern fringe of deepwater area, a farmer told us that he had been growing deepwater rice before by transplanting method as follows; seeds are sown on dry seed bed in early June, transplanted in mid- to late-July and harvested in early to mid-February.

A farmer we met in Long An Prov. told us that when he was in deepwater area he had practiced mixed planting of long-duration deepwater rice (Tai Ngugen, Lua Thom, Trang Tep) and short-duration HYV (IR 64, IR66, MTL 58). Mixing rate of seeds was 70 kg (DWR): 200 Kg (HYV). Grain yield is 2.5 ton/ha from DWR and 4.5 ton/ha from HYV. This is similar to mix planting of Aman and Aus commonly practiced in deepwater area in Bengal (Aiyer, 1949; Ando, 1987).

(B) Backswamp and tidal area

In the south of deepwater area, semi-deepwater or backswamp areas are distributed, a part of them being affected by tidal water. This area was formerly planted to wet season rice once a year, for which double transplanting was a common practice. At present, double cropping of rice is widely adopted. They said that in late 1970's transplanting of local variety in wet season and broadcasting of HYV in dry season was a common practice. Nowadays, HYV such as IR 19660 was broadcasted in both wet and dry seasons, or only in lowlying places local varieties are transplanted. Double transplanting method was abandoned along with the introduction of double cropping system. At CT 15 we saw two methods of nursery. 1) Dry seed-bed: Holes are made at 10 cm spacing in the dry land, 20 seeds / hole are sown, covered with soil and dried grass, watering is done 3-4 times. Seedling age to be transplanted is 20 days for HYV and 45 - 60 days for local varieties. 2) Modified dapok: Mud is spread on the dike of paddy fields, pregerminated seeds are sown.

In this tidal area, farmers are extensively growing tropical fruits such as mango, coconut, orange, longan, lanbutan, in addition to rice.

(C) Triple cropping area

The area around Tien Giang is enjoying relatively favorable water condition. We were told that before 1960 single crop of local varieties was adopted by transplanting, and in the period of 1968 - 1978 double cropping of IR8 was practiced by broadcasting. After the recent introduction of IR36 and IR64, farmers grow rice three times a year by broadcasting.

Farmers told us IR64 is sown on wet land in November and harvested in February, IR36 is sown on dry land in March and harvested in June, and IR64 is sown on wet land in June and harvested in October. They use a small pump for irrigation and drainage.

After harvesting in June, stubbles are burnt without ploughing, water is drained by pump for next seeding, and later let the water get in. Herbicide (Satan) is applied three days after broadcasting, and hand weeding is done after 20 days. Rice fields seemed to be very well managed, and mung beans were planted on the dyke. They are expecting 6 - 7 ton/ha from 1st crop, and 5 ton/ha from both 2nd and 3rd crops. Only in the field for which water control is difficult, transplanting is carried out. A farmer's family we visited owned TV, motor bicycle etc. and seemed to enjoy well-being. To what extent such intensive cropping system is sustainable will be answered in future.

In the area from this highly intensive agricultural area up to Ho Chi Minh, both HYV and tall local varieties which badly lodged were seen. They were at various growth stages.

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5. Observations on Wild and Cultivated Rice in Cambodia

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During the second trip (November - December 1992), Yo-Ichiro Sato and Tadashi Sato visited Cambodia on 12 and 13 December for a preliminary observation on wild and cultivated rice in Cambodia, Taking this opportunity, wild and cultivated rice in the border area of Vietnam was also surveyed.

Observations on wild and cultivated rice are insufficient in Cambodia. Only a few observations have been made before the systematic surveyrance by Cambodia-IRRI project, as far as I am aware (Hamada 1962, Perez 1973, Vaughan 1990). Due to an unstable political situation and long-term economical and social crisis, field tour is still difficult now.

On the outbound trip, we made three and four stops in Vietnam and Cambodia sides, respectively. Near Phnom Penh city, we visited six sites. In Cambodia, Dr. Chaudhary kindly accompanied us. An outline of the trip was described below.

Fig. 5-1. Entrance of Cambodia. At Mocbai.

Trip Route and General Information

Trip route was indicated in Appendix 2-2. We left Ho Chi Minh city early in the morning of December 12 and ran to northwest by route No. 1. On the way, we passed number of hills and valleys with gentle slopes, up to the border to Cambodia. Farmers cleared the slopes and basins of the valleys for paddy fields with narrow dikes. Hill zones are used for housing, graves, public institutions, and sometimes upland fields for vegetables.

Fig. 5-2. Trees remained in paddy fields in Cambodia.

Population density in this area seems to quite high, judging from frequent traffics. We crossed border at Mocbai (Fig. 5-1). No apparent natural barriers were recognized on the border line as far as we observed. When we visited, it took only two hours to complete embarkation and disembarkation. After the border, population density seemed remarkably being lower than that in Vietnamese side. Considerable portion of land remains uncultivated. In particular, the swampy land lies largely waste. Many big trees remain even in rainfed paddy fields (Fig. 5-2). From Mocbai to Phnom Penh, land looks like completely flat, yet it goes down very gently to Mekong river basin.

In Cambodia, traffic facilities are not well organized. Many minor roads sank under flooded water during rainy season, so that water-borne traffic is still important in swampy land. Even the major roads are frequently disrupted by rivers, may cause inefficient transportation.

Outline of the Observation on Natural Populations of Wild Rice

In Vietnamese side, wild rice inhabits quite rarely compared to that in Cambodia side. As mentioned above, rice fields are established only along valleys. We tried to make several stops but could not see wild rice populations except for the site HT12. At the site HT12, a few plants with long panicles inhabited inside road-side ditch with irregular

depth and width. At that site, wild rice was also seen at the fringe of paddy fields near the road. Judging from their plant type, the strain was considered to be a perennial type.

After crossing the border, wild rice was frequently seen in road-side ditch or in big canal. The first observation was made just in front of the immigration office of the Mocbai spot (site CB1). The land was flat but a little bit lower from the road surface (within 0.3 m), and being still wet. A huge natural population of wild rice with a low density inhabited there, and perhaps continued to Vietnam beyond the neutral zone. The plants at the site had high plant height (about 1.5 m or more) and long panicles (25 cm or more). Panicle density (No. of seeds / panicle) seemed to be lower than that of typical annual plants.

Between Mocbai and Phnom Penh, we observed wild rice at two sites. At CB2 site, a population sized 5 m × 50 m inhabited in a road-side shallow ditch (20 or 30 meters wide, less than 1 meter in depth) was observed. The road-side ditch continues more than several kilometers northside of the road. There are many shallow depressions with water. Wild rice populations are often seen beside such depressions.

Another site stands at a road-side deep canal about 50 km southeast of Phnom Penh (CB4). The canal, approximately 30 meters in width, was digged between the road and paddy fields. Water remained partly in the canal. The water level was about 5 meters lower from road surface. A wild rice population that looked like annual type was seen along the shore.

Near Phnom Penh city, big populations are frequently seen in road side ditch, depressions or fringe of paddy fields. We observed six populations among there. At the site CB8, 30 × 200 m sized annual population was observed in a road-side shallow ditch. The land was little lower from the road-surface (less than 0.5 m) but still retained water (less than 5 cm depth), and considered to be disturbed heavily and repeatedly by men and cattle. The plants in the population seemed to be uniform with plant height (about 50 cm) and short panicle length (about 15 cm), but polymorphic for awn color (white and red). Judging by these situations, the plants may belong to annual ones.

Weedy types were also observed in Phnom Penh area. We saw two populations of weedy rice that were both inhabited inside paddy fields. At site CB6, numbers of the plants having big and black kernels that had shattering behaviors were recognized inside a paddy field. Those plants were seemingly derived from a natural hybridization between pure wild and cultivated rice. It was impressive that farmers did not recognize this intermediate types. At the site CB7, some weedy plants were seen beside a big annual-like natural population which inhabited near a paddy field. In both cases, farmers recognized the existence of wild rice, but not so seriously bothered by them.

About ten kilometers west of Phnom Penh city, we saw a huge natural population in a big swamp (site CB10, Fig. 5-3). Wild rice covered whole area of the swamp, shaping enormous number of sub-populations. According to Dr. Chaudhary, the swamp is covered by flooded water, and may become a part of Tonle Sap lake during rainy season. During dry season, on the other hand, a drought is so serious that plants can hardly inhabit there. Due to such strong disturbance, ecological condition is too unstable to reach a climax stage. When we visited there, water remained only in depressions, and sub-populations were scattered at the fringe of such depressions. Area of the swamp seemed not to be smaller than several square kilometers.

Fig. 5-3. A huge wild rice population near Phnom Penh.

Cultivated Rice in Cambodia

We observed native cultivars at only two sites and obtained two strains during the trip. They are all non-glutinous cultivars. Average grain yield based on the interview from farmers was about 1 to 1.5 tons per hectare. In fact, it ranges from 1.2 to 1.9 tons in wet season, according to statistics (Sahai *et al.* 1992). Rice cultivation area, especially floating rice cultivation area has been reducing due to the Pol Pat regime and consequently to loss of cultivars and manpower (Sahai *et al.* 1992).

Our observation was insufficient for cultivated rice, but the collection and evaluation of germplasm were well-organized by the Cambodia-IRRI project. The data of the evaluation for 1270 accessions was published (Sahai *et al.* 1992). Seeding and harvesting time varies according to water conditions; for example, at site CB11, we saw seedlings just after transplanting but harvested straw at site CB2. The proportion of native cultivars to total cultivars is still high.

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6. Wild Rice in the Malay Peninsula

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Wild rice (*Oryza rufipogon*) of Malay peninsula has been surveyed by our previous program (Morishima *et al.* 1984, 1987) which was restricted to south eastern seacoast of Thailand and western seacoast of Malaysia.

In this program, we visited the suburb of Kotabaru, located in northeastern seacoast of Malaysia, where rice cultivation was intensively made in lowland condition. Wild rice was found occasionally and thinly as weed in fringe and dike of the paddy fields, their cover being less than 5 percent. No wild rice was observed away from paddy fields. In this district weeds in paddy field were not so effectively controlled. In paddy field of west seacoast of Malaysia, any wild rice population could not be found, because weeds in paddy field were effectively controlled (Morishima *et al.* 1987).

In 1959, late Dr. I. Hirayoshi (Gifu Univ.) collected several samples of *O. rufipogon* in north eastern seacoast of Malaysia. Unfortunately, their sites of wild rice population could not be informed. Northeastern coast of Malaysia and southeastern coast of Thailand were located closely each other and shared the same climate. However, Malaysian side of transplanting paddy field was different in the degree of wild rice vegetation from Thai side of direct-seeded paddy field where wild rices were frequently found as serious weeds in the paddy field (Morishima *et al.* 1984). Two systems of rice cultivation could bring the difference on wild vegetation of paddy field.

References

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7. Genetic Erosion of Rice in Thailand

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In the central and northeastern Thailand, many natural populations of wild rice (*O. rufipogon*) have been grown in wet or marshy land, such as fringe of ponds, ditches or in abundant fields. These wild rice populations are, however, now vanishing due to a rapid industrialization and road expansion, and loosing genetic diversity within population (genetic erosion). In this report, I evaluate the level of genetic erosion of wild rice in north and northeastern Thailand by using the records on the observations at the natural populations. Also, we describe the reduction of genetic variation for cultivated rice, particularly the loss of indigenous cultivars.

The present data consists of the records taken in 1983 and 1991 or 1992. In 1983, we visited 20 populations of wild rice that were along major roads between Bangkok and Nongkai (route No. 2), and between Bangkok and Phitsuanulok (route No. 1) for the observation of genetic resources of wild rice. In 1991 and 1992, we visited the same sites as in 1983, and took same kinds of record as did in 1983.

Materials and Methods

Record taken in 1983: In December of 1983, we visited many sites for the natural population of wild rice that were along route No.2 from Bangkok to Nongkai, and along route No. 1 from Bangkok to Phitsanulok. These sites were apriori settled when we found population along the roads. At every site, the size of the population, density (cover of rice plant), height and growth stage of rice plant, water condition and topography of the land, accompanying weeds etc. were recorded. The geographical position of the sites was recorded on maps issued by Defense Mapping Agency Center (ONC K-9B, J-10C and ONC J-11D, scaled at 1: 500,000) by the distance from nearest big junction of roads.

Records taken in 1991 and 1992: In December of 1991 and December of 1992, we tried to visit the same sites as visited in 1983. In 1991, the sites in northeast were visited. In 1992, those in north were visited. In total, 21 sites for wild rice could be identified (Fig. 7-1). The items recorded were the same as ones done in 1983, except the positioning that was done by using a Global Positioning System (GPS, SONY IPS-360). Localities of the sites were given by this system.

Results and Discussion

A map of observation sites was illustrated in Fig. 7-1. The population of wild rice at the 9 sites mostly vanished during this eight (or nine) years due to the road expansion (4 sites) and the constructions (1 site). But for other 4 vanished populations, such obvious changes were not recognized. Those sites that vanished were mostly located near Bangkok (The distance from center of Bangkok city was less than 150 km). At the four sites, the ditch at which the population inhabited was filled up, and thus the populations were buried completely (Fig. 7-2).

In 8 sites far from Bangkok city (farther than 150 km from Bangkok), populations of wild rice remained without remarkable differences in their size and density during this eight or nine years except for a site near Nongkai. Those sites are located in road side ditch, irrigation canal or fringe of lake, and seems to be humid throughout year still now.

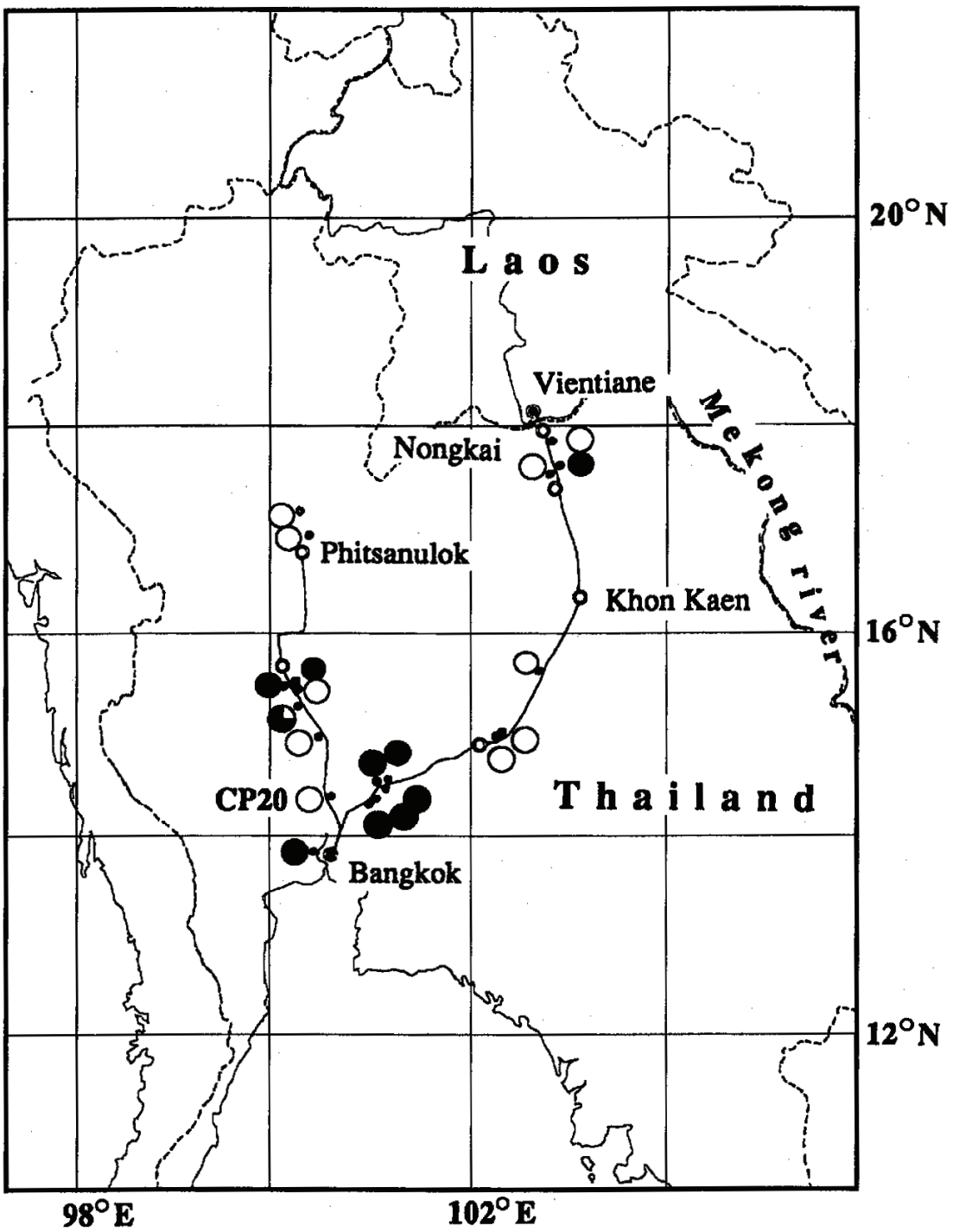

Fig. 7-1. Observation sites in north and northeast Thailand for the evaluation of genetic erosion of wild rice. Black part of each circle shows the proportion of biomas reduced within this decade.

Fig. 7-2. A site buried by expanding a major road (at Saraburi, 110 km northeast of Bangkok). A wild rice population had ever seen under the right lanes,

Only an exceptional case that maintain the size and density of wild rice population near Bangkok was seen at Site CP20. At this site, the population size has been enlarged about 3 times during these nine years. Wild rice population invaded neighboring paddy field at which farmers stopped to cultivate rice since 1990. However, the plants absorbed considerable number of genes from cultivated rice, judging by genetic studies. Therefore, the plants are more or less weedy.

It was indicated that the vanishing rate of wild rice population in Thailand was rapid. We need to conserve them in gene banks and in the natural stands (*in situ* conservation), both. A possibility of *in situ* conservation program is now under consideration in my institute with a collaboration on the present program.

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8. Observations at Permanent Study-Sites of Wild Rice in the Suburb of Bangkok

Hiroko MORISHIMA (National Institute of Genetics, Yata, 1111 Mishima 411, Japan)

After a general survey of wild rice in Thailand carried out in 1983, we fixed eight permanent study-sites inhabited by *O. rufipogon* in the suburb of Bangkok, including a few sites which we had monitored since 1970's. The objective set up in the beginning of this project was to obtain a deeper understanding of population dynamics of *O. rufipogon* from demographic-genetic standpoints. Since then, we repeatedly visited the study-sites in different seasons and in different years, to take records of habitat conditions, both biotic and abiotic, and characteristics of wild-rice populations. Seed samples were collected when available for genetic experiments to be carried out in Mishima. We now realized that we are the witness of drastic environmental change due to rapid urbanization occurring in the surrounding of Bangkok and of the consequent destruction of agroecosystem in which cultivated as well as wild rice had lived for a long time.

Seven out of eight original populations and a few newly added populations have been monitored up to now. As shown in Fig. 8-1, four annual populations, which are now nearly extinct, are at the fringe of Central Plain facing to the Korat highland. While, perennial populations are in the deeper center of the Central Plain. When this project started, rice field were spreading in the surrounding of our study-sites, but most of them disappeared during the last decade. Wild-rice populations are also threatened by destructive environment development.

Observations During 1991-1993

Details of description of each study-site and the results of observations before 1990 are given in our previous trip report (Morishima *et al.* 1991). Observations during 1991-1993 are given below.

NE1 (14° 31' N, 100° 55' E, 2 km south of Saraburi)

Perennial/annual heterogeneous population in a roadside ditch and a huge annual population in an adjacent army-camp ground.

1991. 12 Camp ground was cleanly managed and most wild-rice plants were removed.

1992. 12 In ditch, no wild rice was found, though many other grasses and sedges were growing. In camp site, no wild rice was seen at least near the gate.

1993. 3 In camp site, almost no vegetation was seen possibly because of drought.

NE2 (14° 32' N, 100° 57' E, 7 km east of Saraburi)

Annual population which fully occupied roadside ditch when found in 1973 and gradually declined. Since 1985, no wild rice was found.

1993. 3 Due to road expansion, precise location of the original site could not be identified.

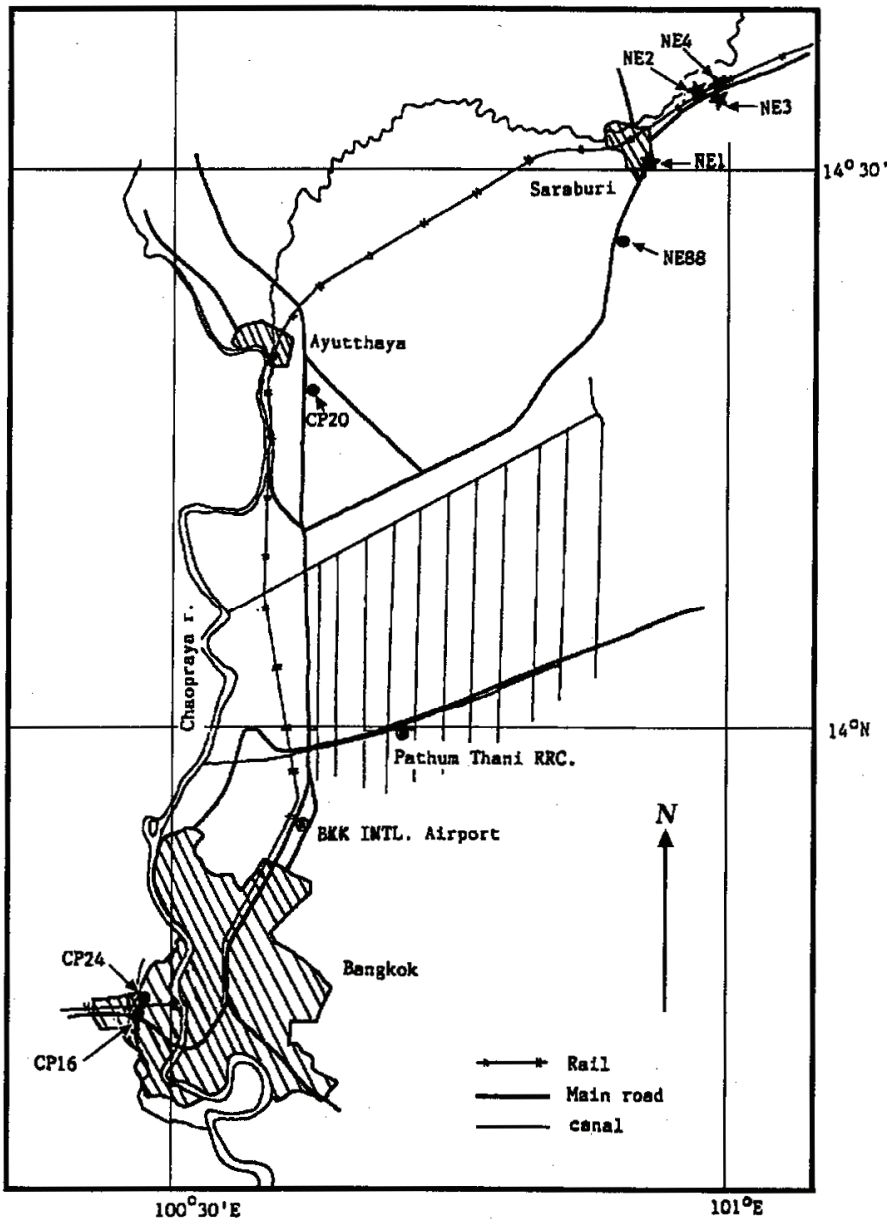

Fig. 8-1. Location of study-sites in Bangkok area. Star: annual population, solid circle: perennial population.

NE3 (14° 34' N, 100° 57' E, 11 km E of Saraburi)

A large annual population spreading in the roadside waste land.

1991. 12 Northern half of the site (our observation area) was destroyed by road expansion. South of the previous observation area: completely dry, 122 wild rice plants/50 × 50 cm, 90% cover, 100 cm plant height.

1993. 3 Young plants were scarcely growing. Damage by grazing and drought seemed to be severe.

NE4 (14° 34'44" N, 100° 00'01" E, 12 km E of Saraburi)

An annual population growing in roadside marshy place surrounding a small depression. In 1989, the observation site was completely reclaimed.

1991. 12 At the outer fringe of reclaimed land, wild-rice plants were still growing. Water depth: 0 cm (roadside) - 40 cm < (north and east side), pH: 6.8 - 7.7.

1992. 12 Not big change, wild rice plants were growing in water at the fringe.
1993. 3 Water depth: dry - 50 cm, wild rice had 20% cover at the fringe, 50 - 70 cm plant height.

NE88 (14° 26'N, 100° 54' E, 4 km north of Hinkong)
A perennial population distributed ranging over 500 m in a roadside ditch.
1991. 12 Habitat was completely destructed by road construction.
1992. 12 No wild rice.
1993. 3 The ditch was deepened for road construction and heaped with soil. No wild rice.

CP20 (14° 19' N, 100° 37 E, 2 km south of Ayuthaya)
Perennial population distributed in and at the fringe of a deepwater rice field.
1991. 12 Not big change. Water depth: 30 cm.
1992. 3 Road was expanded about 20 m.
1992. 12 Wild rice was more abundant than before probably because of abandonment of cultivation. Water depth: 20 cm or less, plant height 1.5 - 1.8 m.

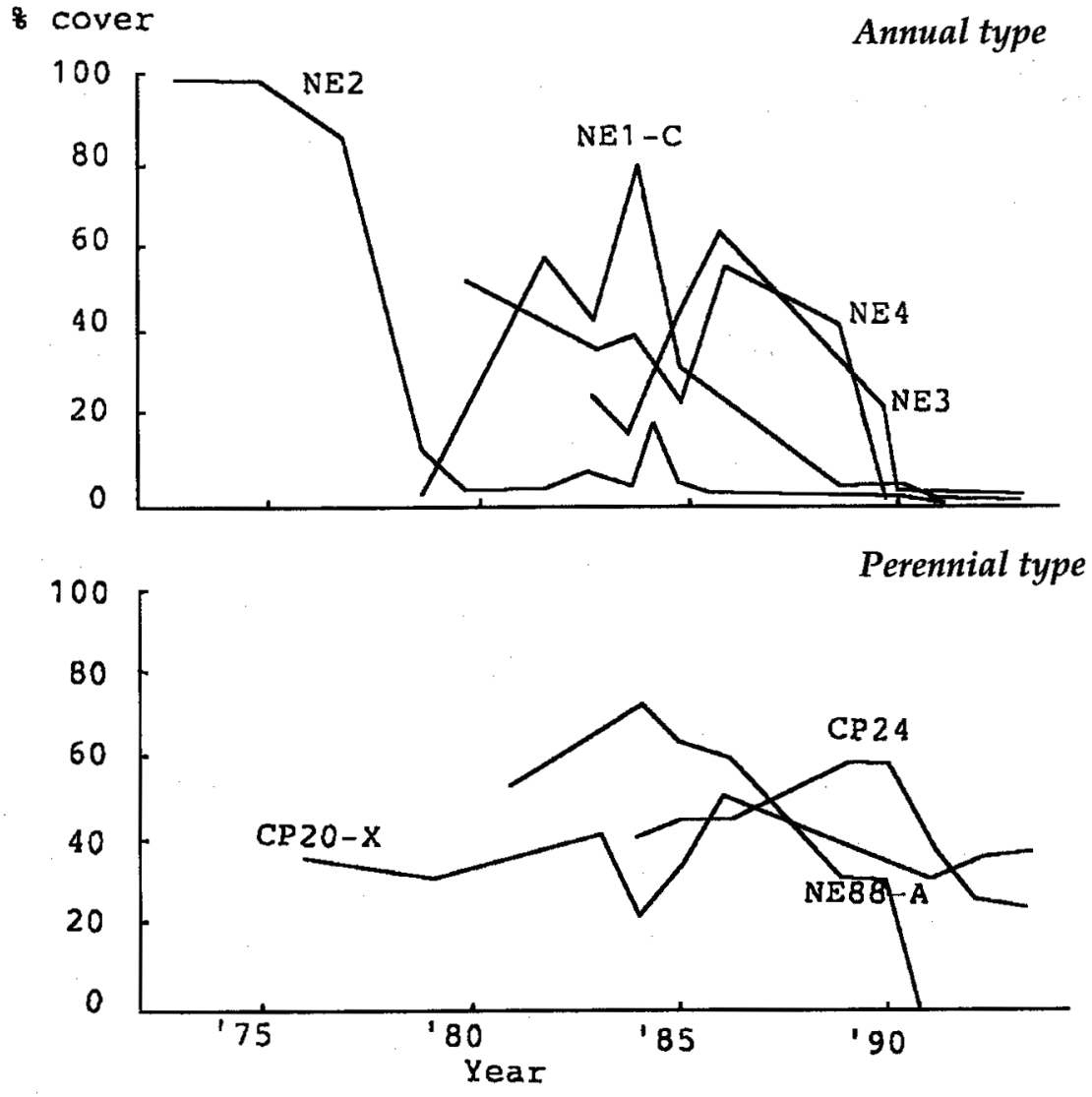

Fig. 8-2. Population flux of annual and perennial types of wild rice shown by % cover.

CP16 (Bangkok Noi)
A perennial population consisting mostly of sterile plants
1991. 12 Water depth: 0 - 30 cm, one small flowering panicle of *O. rufipogon* (sterile) was found, many *O. officinalis* plants were scattered in the forest.
1992. 12 No change.
1993. 3 Wet soil, wild rice seemed to increase, 1.5 m plant height, a few flowering plants were found, most plants were at the vegetative state.

CP24 (14° 48'16" N, 100° 28'34" E, 300m W of Wat Challow)
A perennial population in a riverside deepwater area growing together with *O. officinalis* and *O. ridleyi*.
1991. 12 Water depth: 10 - 30 cm, Panicle length: 29 - 32 cm, pH: 6.8 - 7.4.
1992. 3 Shallow water. A few *rufipogon* plants had panicles which already shed seeds. *O. officinalis* plants were at the flowering or maturing stage.
1992. 12 Fertile plants were heading (seeds collected), plants with wide leaves were before heading.
1993. 3 Wet soil, a few plants with sterile panicles.

Red Data of Wild Rice

Population flux of wild rice at our study-sites

Fig. 8-2 shows population flux of annual and perennial-type wild rice at our permanent study-sites. The ordinate indicates rough estimate of % cover of wild-rice plants within the observed area. As already stated in our previous trip report (Morishima *et al.* 1991), all annual populations we had monitored became nearly extinct before 1990. The reason for extinction was catastrophic destruction of the habitats due to environmental development, except for NE2 population which was gradually replaced by perennial competitors.

On the other hand, perennial-type populations were relatively stable. In 1991, however, NE88 site (roadside ditch) was destroyed by road construction, and wild rice completely disappeared. Other perennial populations still persist in 1993. CP20, which was growing in and at the fringe of a deepwater rice field, seems to have become abundant since 1992 probably due to abandonment of rice cultivation. CP16, which was a small perennial population characterized by complete sterility, seemed to have once disappeared after habitat disturbance. In 1992 and 1993, however, some individuals could be observed again. This variant type of populations exclusively distributed in this riverside deepwater area seems to be tolerant to a certain degree of habitat disturbance and able to persist with a strong vegetative propagating ability. Details of this variant type of populations will be given in the next chapter.

Extinction and recolonization

Through this long-term observation, we felt that it is easier for us to observe extinction events than to observe colonization events. It was a rare case that we could trace the fate of one annual population (NE1-C) from its colonization into a vacant habitat (1980/81) to its extinction (1990/91).

In an attempt to obtain demographic data, we set up several 50 cm × 50 cm quadrats at each study-site, and tried to take demographic data whenever we visited the sites. Since habitats were frequently disturbed, long-term observation on the basis

of small quadrats was difficult. Yet, it was attempted to assess local extinction rates within site (quadrat basis) for two annual and two perennial sites. Extinction rate was estimated according to the Slatkin's model (1977),

$$(1-e_o)^T=X$$

in which e_o, T and X stand for extinction rate, number of years observed and proportion of extant quadrats after T years, respectively. Extinction of whole population by habitat destruction was not included in this computation. Each population analyzed as a whole persisted during T years without showing distinct decreasing trend. This suggests that respective quadrats became partly extinct but new patches were established. As shown in Table 8-1, in annual populations NE3 and NE4 which are recruited mostly by seedlings, extinction on a small scale occurred more frequently than in perennial populations NE88 and CP20. High rate of extinction observed in CP20-X (weedy type in a floating rice field) may be explained by habitat disturbance by rice cultivation and enforced high rate of seed propagation of potentially perennial plants.

Table 8-1. Propagating system and local extinction rate estimated at permanent study-sites.

Population	No. of quarats	Seedling [1] %	Local exinction
NE3	6	100 + 0	0.040
NE4	7	99.6 + 0.5	0.055
CP20X	3	72.0 + 2.2	0.078
CP20Y	4	19.8 + 8.7	0.000
NE88	4	6.3 + 8.2	0.004

1) Seeding % of total plant no. (seeding + vegetative propagule) observed in the early rainy season, averaged over 2-9 times census.
2) Estimated from Stalkin's model. See text for detail.

Judging from fugitive habit of annuals thus revealed, colonization events might have frequently occurred not only within population but also to neighboring sites establishing new populations. In fact, near NE4 site, we found many populations of similar annual wild rice after extinction of NE4, though we are not sure they were present since long before, or colonized recently.

A Variant Type of *O. rufipogon* Found in the Western Fringe of Bangkok

In 1983, we found a small population of wild rice (CP16) which was similar to *O. rufipogon* but had unique morphology in a deepwater area along the Bangkok Noi canal. They had tall stature, wide leaves and completely sterile spikelets. Until now, we found six similar populations in the area. This type of plants seems to be frequently distributed in this limited area. No normal population of *O. rufipogon* was found within this area.

Habitat: Deepwater area along the Bangkok Noi canal, about 0 m alt. Maximum water level reaches 1- 2 m in the end of rainy season (Oct. - Dec), and in dry season the soil still retains moisture. The growing sites of wild rice are open or half-shaded place located at the fringe of forest. No cultivated rice fields are seen nearby. pH of water ranged from 5.6 to 6.8. Their habitats are found near the housing place of local people and disturbed in varying degrees.

Table 8-2. Phenology of a variant type of wild rice found in the western fringe of Bangkok

Month	Variant type population					Control		
	CP16	CP24	CP34	CP37	CP38	CP48	NE88	CP20
Jan	S+F(85)					V(85)	V(85)	
Feb	S(86)	S(86)					V(86)	
Mar	S(93)	S(92)	S(92)	S(92)		S(93)		-(92)
		S(93)	S(93)	S(93)				
Apr								
May	V(90)	V(90)					V(90)	V(81)
								V(90)
Jun	V(85)	V(85)					V(83)	V(84)
							V(85)	V(85)
Jul								
Aug	V(84)	V(84)					V(83)	V(84)
Sep								
Oct								
Nov	S(85)	S(89)					F(89)	F(77)
	-(89)							F(85)
Dec	S+F(83)	F(85)	S+F(91)	S(91)	S(92)		F(83)	F(80)
	-(89)	S+F(89)	S(92)	S(92)			F(85)	F(83)
	F(91)	S+F(91)					F(91)	
		S+F(92)					F(92)	

S: Sterile plants were flowering
F: Fertile plants were flowering
V: Vegetative stage
-: Wild rice not found
(): Year of observation

Morphology and fertility: Most plants of these populations have tall stature (depending on water condition), big panicles (30-40cm), wide leaves (sometimes wider than 3.0cm<), big stigma and deformed anthers. Anthers are whitish and contain completely sterile pollens. These sterile plants we have observed are similar with each other in general morphology, but polymorphism found in apiculus color indicates that they were not derived from one genet. Sometimes, abnormality in flower organs was observed, such as extra stigma and abnormal lemma and palea. This abnormality was most frequently found in CP37.

Interestingly, morphologically normal (narrow leaves) and fertile plants were found with low frequency growing side by side with sterile plants having wide leaves. Relative frequency of sterile and fertile panicles flowering in December of 1991 at CP34 was about 4:1. No difference in morphology was found between those fertile plants and ordinary *rufipogon* plants.

Phenology: They develop many new shoots from old stem nodes after May and survive deepwater with a high floating ability. As shown in Table 8-2, we observed flowering from November to March, though only a few tillers bear panicles, many others remaining in vegetative state. The long duration of flowering season and low rate of reproductive tillers found in this type of populations are contrasting to behavior of normal *rufipogon* plants of perennial type which flower in November to December controlled by strong photoperiod-sensitivity. In these variant types, flowering of fertile plants was observed only before January, while flowering panicles in February and March were exclusively sterile ones (Table 8-2). Local people at CP24 once told us that they had never seen the flowers of plants with wide leaves growing in front of their house.

Chromosome: Somatic chromosomes of two sterile plants were examined by the cooperation of Dr. R. Ishikawa. One plant from CP16 was triploid (2n=36), but one from CP24 was diploid. Variation in chromosome number among individuals within populations should be elucidated.

The origin of this variant type and relationship with the normal *O. rufipogon* remain unanswered. It is not confirmed that to what extent leaf width - flowering time - sterility are strictly associated. This might be the incipient stage of differentiation of a variant type within species. Since this type has vigorous vegetative propagating ability, their populations seem to be tolerant to a moderate environmental disturbance. Yet, catastrophic destruction of environment will inevitably expel their natural populations.

Conclusion

(1) Local extinction rate within population (quadrat basis) was higher in annuals than in perennials, suggesting the fugitive habit of the annual populations. This could be extrapolated to population level dynamics.

(2) Irrespective of the differential response to habitat disturbance between the perennial and annual populations, drastic environmental development occurring in the suburb of Bangkok brought about catastrophic extinction of most of our study-populations, both perennial and annual types.

(3) Unique type of *O. rufipogon* populations distributed in the western fringe of Bangkok might represent the incipient stage of speciation. Those populations could serve as a good material for studying speciation mechanism, cytological population dynamics and developmental genetics.

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9. A Report for an Additional Trip in Laos Made in 1993

Yo-Ichiro SATO (National Institute of Genetics, Yata, 1111 Mishima 411, Japan)

In December of 1993, Yo-Ichiro Sato and Tadashi Sato visited Laos again, to observe the change of some wild rice populations near Vientiane city. Also, we discussed about the possibility of *in situ* conservation in Laos with authorities. Here I report on the change that happened in some wild rice populations and on wild rice populations that were visited newly this time.

Change of Wild Rice Populations in their Biomass

During the previous projects (cf. Morishima *et al.* 1984, 1987, 1991), we have been observed several wild rice populations near Bangkok city (called permanent sites), to trace the long-term change in their biomass and their circumstances. Many of them completely vanished during the last decade, so that we could not continue the trace. We needed to establish new permanent observation sites. New ones should satisfy conditions described below.

1) The site(s) should be placed at wet-land at which enough amount of water is naturally supplied.

2) The site(s) should be at convenient place in terms of traffics for frequent visit.

3) The site(s) should be expected to maintain itself without catastrophic change such as construction of road, factories or other buildings for ten years or more.

Some sites that were observed in Vientiane area in 1991 may satisfy these conditions, as explained later. As mentioned in the previous report (p. 199), we visited eight natural populations of wild rice near Vientiane area in 1991. In 1993, we visited three of them to compare population size, rice plant cover, water condition and other circumstances.

LV8: This population inhabited a huge abundant land in 1991. In 1993, however, vegetables were grown there. No wild rice was seen around the land as far as we observed.

LV9: In 1991, we saw a natural population at the fringe of several small ponds. Weedy type was also observed inside paddy fields near the ponds. In 1993, we saw many plants of wild rice scattered at the fringe of the ponds (Fig. 9-1), but not in the paddy field. The size and rice plant cover of the population in the pond seem stable during these two years. The farmer of the field told us not to know the existence of the weedy type in his field.

LV10: The site is located along major road from Vientiane to Tadhua spot bound for Nongkai. A huge wild rice population inhabited a road side pond in 1991. In 1993, we saw the population there (Fig. 9-2). The size and rice plant cover of the population

seemed to be stable during these two years. This population seems to satisfy conditions for a new permanent observation site and for *in situ* conservation of wild rice population in Laos.

Fig. 9-1. A view of site LV9.

Fig. 9-2. A view of site LV10. *In situ* conservation will be tried at this site.

New Sites Visited in 1993

The sites visited in 1993 were indicated in Appendix 2-1 and Appendix 4. We visited 9 sites. Of them, four were for wild and six were for cultivated rice. At Site LV25, we observed wild and cultivated rice both.

As T. Sato mentioned in report sect. 3, paddy fields in Vientiane plain are mostly classified as rainfed lowland field. In fact, the five sites out of the six were all of that type. Site LV29 was a typical upland field. At Sites VT21～23, fields and surrounding lands completely dried up when we visited, due to a strong drought. According to a farmer working at Site VT23, yield of this year was about 0.8t / ha, while 1.2～1.5t / ha in usual years.

Wild rice populations that we visited were all located north of Vientiane city. At Site LV25, we observed a weedy type that was invading a paddy field. Some of plants obviously resulted from natural hybridization between wild and cultivated rice, *i. e.*, plants having an appearance of cultivated rice with non-glutinous endosperm, with long awn or with strong shattering behavior. Some plants having an appearance of wild rice inhabited dikes and inside road-side ditch. Site LV26 and LV27 were both inhabited by pure wild rice. Both sites were distant from a major road, so that we took off the car and walked to the sites. Site LV26 was in a shallow but big depression surrounded by paddy field which were already harvested, while the wild rice reached at maturity stage. The population had a round shape with about 100 m diameter. Plant height was about 1.2-1.5 m. Panicle length was about 20- 25 cm. Site LV27 stood in a pond whose diameter is about 100 m, which was surrounded by forest. There were no paddy fields around the site, as far as we saw. The site seems to be appropriate for *in situ* conservation. Site LV28 also stood in a big and shallow depression, but too far to close up for observation.

Laos is still quiet, and seemed to be still isolated from modernization and industrialization. From the viewpoint of conservation of genetic resources, the situation is quite preferable. Yet, the wave of modernization and industrialization undergoes undoubtedly in this country, particularly in Vientiane. A new bridge that will be opened across Mekong river between Thadua and Nongkai in 1994 would carry heavy traffics from Thailand to Laos. It will result in the expansion of the road in Laos. I am afraid of extinction of wild rice populations, that have been occurring in Thailand during the last two decades.

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Appendix 1. Abstract of Diary

1. Laos and northeast Thailand (Dec. 2～19, 1991):

Y.I. Sato and T. Sato (Dec. 2 - Dec. 19); H. Yamagishi (Dec. 2 - Dec. 17); H. Morishima (Dec. 2 - Dec. 17); S. Chitrakon (Dec. 3 - Dec. 16); K. Ando (Dec. 13 - Dec. 19)

December, 1991

2 Arr. Bangkok (Sato, Sato, Morishima, Yamagishi). (TG 641) Stay: Golden Dragon Hotel.
3-4 Field trip to permanent observation sites near Bangkok.
5 Bangkok-Vientiane (TG 690). Visit: Lao-IRRI Project (Dr.J. M. Schiller and Dr. S. Pushpavesa). Stay: Lane Xang Hotel.
6 Vientiane-Luang Prabang (QV 200). Obs. sites: LL1-LL7. Stay: Luangprabang Hotel.
7 Field trip. Obs. sites: LL8-LL12.
8 Luangprabang-Vientiane (QV 201). Stay: Lane Xang Hotel.
9 Vientiane-Phakse (QV 302). Obs. sites: LP1-4. Stay: Souksamlane Hotel.
10 Field trip. Obs. sites: LP5-11.
11 Phakse-Vientiane (QV 303). Obs. sites: LV1-LV6. Stay: Lane Xang Hotel.
12 Field trip. Obs. sites: LV7-9. Visit: Lao-IRRI Project.
13 Vientiane-Nongkai-Udon Thani. Obs. sites: LV10, NE34-36, NE91-92.
14 Udon Thani-Khon Kaen. Visit: Dr. S. Miyagawa, Obs. sites: NE93-97.
15 Khon Kaen-Nakhon Ratchasima. Obs. sites: NE6-10, 13-15, 98.
16 Nakhon Ratchasima-Bangkok. Obs. sites: NE85-87, 99.
17 Lv. for Osaka (TG 622) (Yamagishi), for Tokyo (TG 640) (Morishima)
17-18 Field trip for permanent observation sites around Bangkok.
19 Lv. for Tokyo (TG 640) (Sato, Sato, Ando)

2. Malaysia, Thailand and Taiwan (Feb. 29 - Mar. 12)

Y. Shimamoto and T. Sato (Feb. 29 - Mar. 12); Y. I. Sato (Mar. 5 -12)

February, 1992

29 Arr. Kuala Lumpur (CX 721) Visit: Dr. S. Iyama (UPM)

March

1 Visit: Agricultural park
2 Kuala Lumpur - Kota Baru. Visit: MARDI (Drs. Nemoto and L.K. Hup)
3 Field trip. Obs. sites: MK1,2
4 Field trip. Obs. sites: MK3-7
5 Kota Baru- K.L.- Singapore- Bangkok
5 Arr. Bangkok (Y.I. Sato) (TG 641)
6 Visit: Rice Research Institute (Dr. Y. Tanaka). Field trip. Obs. sites: CP24
7 Field trip. Obs. sites: CP25, 34
8 Field trip. Obs. site: CP20
9 Bangkok- Taipei (CX 712/462), Taipei-Taichung
10 Sato & Sato. Field trip. Shimamoto. Visit: National Chung Hsing Univ. (Drs. F.S. Theng and M. S. Yeh)
11 Sato & Sato. Field trip. Shimamoto. Visit: Taiwan Tea Exp. Stat. (Drs. I. M. Juan, M. L. Lin and Mr. C. Hsuan)
12 Shimamoto. Visit: National Taiwan Univ. (Drs. S.H. Huang, Y.C. Huang, W. H. J. Kuo. Taichung- Taipei, Lv. Taipei for Osaka (CX 564)

3. Vietnam and Cambodia (Dec. 7～20, 1992):

Y.I. Sato, T. Sato, K. Ando (Dec. 7～20); H. Morishima (Dec. 7～17); S. Chitrakon

December, 1992

7 Arr. Bangkok (Sato, Sato, Ando) (TG 621)
8 Field trip. (Bargkok)
9 Bangkok- Ho Chi Minh (TG 680). Stay: Saigon Hotel.
10 Ho Chi Minh- Can Tho. Visit: Can Tho University. Obs. sites:HTl～6. Sato and

Sato

11 Can Tho-Ho Chi Minh. Obs. sites: HT7,8. Stay: Saigon Hotel.

12 Ho Chi Minh- Phnom Penh. Met by R. C. Chaudhary. Obs. sites: HT9～12, CB14. Stay:

13 Phnom Penh- Ho Chi Minh. Obs. sites: CB5～11. Stay: Saigon Hotel.

14 Field tour for eastern seacoast. Obs. site HT13.

15 Visit: Botanical garden, Morishima, Ando, Chitrakon

11 Visit: Agr. Tech. Center (Cao Lanh). Trip for Dong Thap Province. Stay: Food Company Guest House

12 Study tour in Tam Nong District. Obs. sites: CT1～5

13 Tam Nong- Can Tho. Obs. sites: CT6～8, HT14, 15.

14 Visit: Gene Bank of Mekong Delta Farming Systems R & D Center, etc. Obs. Sites: CT11～17.

15 Can Tho- Ho Chi Minh. Obs. sites: HT16～19. Sato, Sato, Morishima, Chitrakon, Ando

16 Ho Chi Minh- Bangkok (TG 681)

17 (Morishima and Ando) Lv. for Osaka (TG 622) (Sato and Sato) Field tour for north. Bangkok-Phitsanulok. Obs. sites:

18 Phitsanulok-Sukotai- Nakon Sawan. Obs. sites:

19 Nakon Sawan- Bangkok. Obs. sites:

20 Lv. Bangkok (TG 622)

4. Observation of wild rice around Bangkok (Mar. 15～20, 1993):

Y. Shimamoto (Mar. 15～19); H. Yamagishi (Mar. 17～20); S. Chitrakon

March, 1993.

15 Arr. Bangkok (Shimamoto) (CX 481). Stay: Golden Dragon Hotel.

16 Arrangement of survey schedule of wild rice.

17 Observation of wild rice fields. Obs. sites: CP16, 24, 34, 36, 37, 48. Arr. Bangkok (Yamagishi) (TG 621).

18 Observation of wild rice fields. Obs. sites: CP25, NE1～4, 88, 90.

19 Observation of wild rice fields. Obs. sites: CP45, 46. Lv. Bangkok (Shimamoto) (CX 480).

20 Lv. Bangkok (Yamagishi) (TG 622).

5. Laos (Nov. 27 ～ Dec. 7)

Y.I. Sato, T. Sato

November, 1993

27 Arr. Bangkok (TG 621). Hotel: Golden Dragon Hotel.

28 Field trip. Obs. sites: CP20, NE3, 4, 88, 90

29 Visit: King's project.

30 Bangkok- Vientiane (TG 690). Visit: Dept. of Agr. & Extension (Mr. Latsanibong). Hotel: Lane Xang Hotel.

December

1 Visit: Lao-IRRI project (Dr. Schiller, Mr. Viravanh). Obs. sites: LV8,10, 21～23.

2 (morning). Field trip. Visit: LV9

3 Visit: National Agric. & Seed Center. Field trip. Obs. sites: LV24～29.

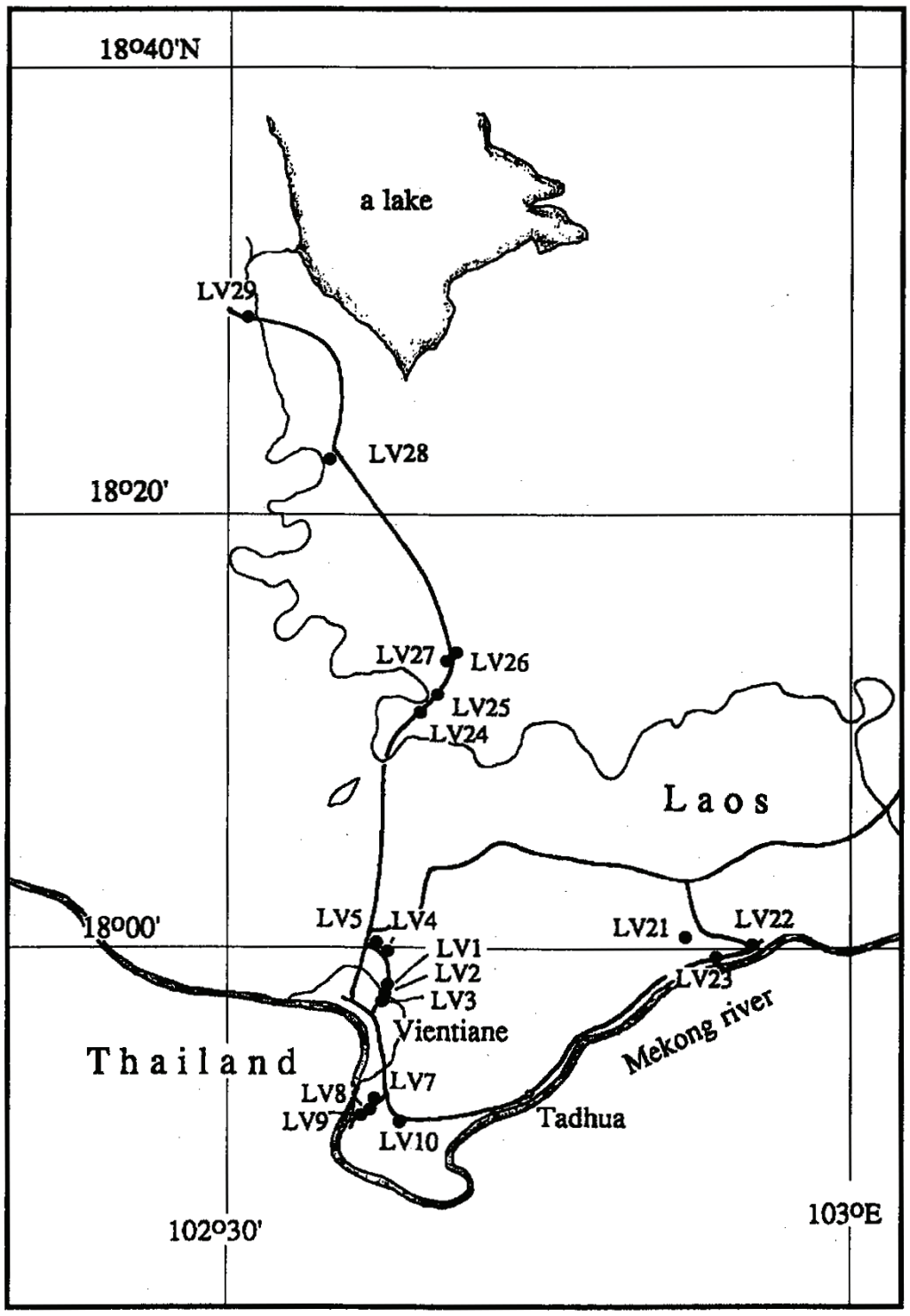
4 Vientiane- Bangkok (TG 691).

5 Field trip. Obs. sites: CP49, 51

6 Visit: Dept. of Agr. (Mr. Montri, Dr. Boriboon).

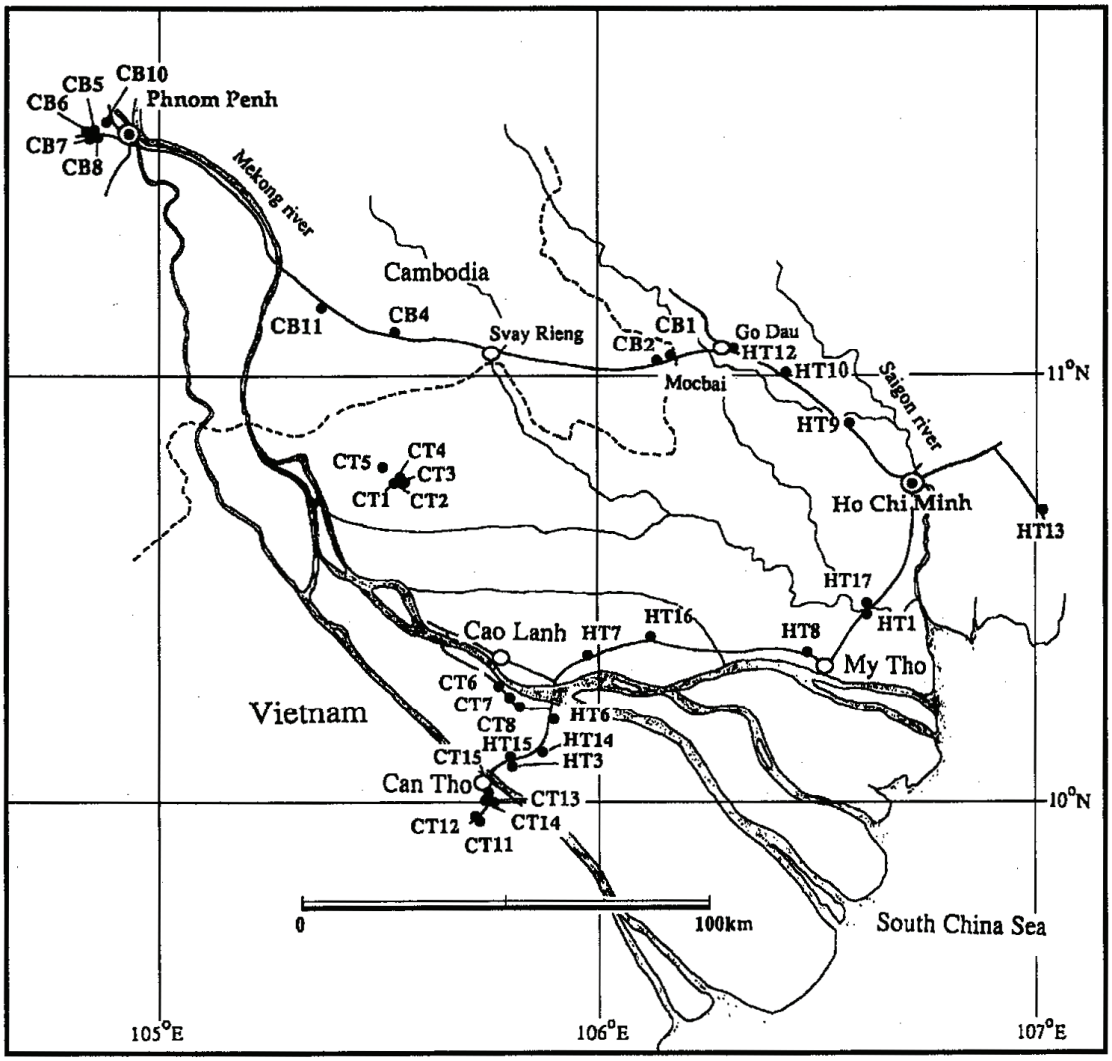
7 Lv. Bangkok (TG 622)

Appendix 2-1



A map of collection sites near Vientiane.

Appendix 2-2



A map of collection sites in Cambodia and Vietnam.

Appendix 3. Persons and Institutions to be Ackowledged

We thank persons and institutions described below for their collaboration.

LAOS

Mr. Kou Chansina (Director General), Mr. Latsanivong Amarathithada (Deputy), Mr. Phoumy Inthapanya (Breeder), Department of Agriculture & Extension.

Mr. Viravanh Phannourat (Director), Mr. Bounxou Kentza, National Research & Seed Production Center.

Dr. Suvit Puchipavesa (former expert), Dr. J. M. Sciller (team leader), Lao-IRRI Project.

CAMBODIA

Dr. Ram C. Chaudarhy (Expert), Cambodia-IRRI project.

VIETNAM

Prof. Vo Tong Xuan (Vice rector), Can Tho University.

Mr. Voung Dinh Tri (Head), Mr. Le Viet Dung, Department of Genetics & Plant. Breeding, Can Tho University.

Mr. Le Thanh Duong (Deputy Director), Mr. Huynh Quang Tin (Head of gene bank), Mr. Nguyen Hgoc De, Mekong Delta farming Systems Research and Development Center, Can Tho University.

Mr. Nguyen Phuoc Tuyen (Director), Mr. Bay, Agricultural Technology Center, Dong Thap Province.

THAILAND

Mr. Montri Rumakom (Director General), Dr. Boriboon Somrith (rice expert), Department of Agriculture.

MALAYSIA

Dr. Nemoto,MARDI.

Prof. Shin-ya Iyama, UPM.

JAPAN

Dr. Ikuo Nakamura (Iwate Biotechnology Research Center).

Dr. Syuuji Miyagawa (Faculty of Agriculture, Gifu University).

Dr. Ryuuji Ishikawa (Faculty of Agriculture, Hirosaki University).

Prof. Mitsuru Hotta (Faculty of Science, Kagoshima University).

Mr. Khamsing Sayakone (Ambassador), Mr. Ampoy Kindavong (Attach), Lao embassy of Tokyo.

Ms. Chantason Inthavong.

Dr. Wen-Bing Chen, Mses. Ryouko Hirabayashi, Sonoko Saeki, Chieko Asaka, Yumiko Noguchi and Haruko Masuda (National Institute of Genetics).

Ms. Michiko Wakita, Mr. Tatsuya Saito (Saiyuu Travel Co. Ltd).

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Appendix 4

List of collection sites in Laos, Vietnam, Cambodia, Malaysia and Thailand.

Site No.	Latitude (N)			Longitude (E)			Place	Topo.	Type
	°	'	"	°	'	"			
Laos									
LL 1	nr			nr			Near Luangprabang Hotel	RA GS	C
LL 2	nr			nr			do	RA GS	C
LL 3	nr			nr			do	RA GS	C
LL 4	19	52		102	10	29		RA GS	C
LL 5	nr			nr			10km S of Luang Prabang	nr	C
LL 6	19	50	41	102	10	29		RA GS	C
LL 7	nr			nr			10 mins walk from LL6	UF GS	W
LL 8	19	51	44	102	06	37		RA FL	C
LL 9	19	49	19	102	02	41	Ban Nahpo vil.	RA FL	C
LL10	19	46	36	101	58	50	Ban Ou vil.	RA FL	C
LL11	19	45	10	102	01	30	16.7km SW of LL8	nr	C
LL12	19	50	54	102	05	11	2.4km SW of LL8	UF GS	C
LP 1	15	07	31	105	48	41		RA FL	C
LP 2	15	09	33	105	46	09		PO	W
LP 3	15	12	54	105	44	06		DT	W
LP 4	15	12	31	105	43	53		PO	W
LP 5	15	06	52	105	49	41	2.7km N of Phakse	DT	W
LP 6	15	04	01	105	43	59	13km SE of Phakse	UF GS	C
LP 7	15	03	22	105	54	32	16km SE of Phakse	PO	W
LP 8	15	00	54	105	54	34		RA FL	C
LP 9	14	50	14	105	50	10	Ban Nong Sa	PO	W
LP10	14	50	46	105	49	29		PO	W
LP11	14	52	07	105	52	38		PO	C
LV 1	17	57	38	102	38	45		DT	W
LV 2	17	57	37	102	38	47		RA FL	C
LV 3	17	58	32	102	39	27		PO	W
LV 4	17	59	54	102	39	26		PO	C
LV 5	18	01	48	102	39	20		RA	W
LV 6	nr			nr				RA FL	W
LV 7	17	52	02	102	37	05		PO	W
LV 8	17	51	47	102	36	31		FL	W
LV 9	17	52	25	102	36	43		DT & WD	W & C
LV10	17	52	25	102	39	19		PO	W & C
LV21	18	02		102	50			RA	C
LV22	18	00		102	56			RA	C
LV23	17	59		102	54			PA	C
LV24	18	11	37	102	40	36		RA	C
LV25	18	13	41	102	41	49		WD & RA	W & C
LV26	18	14	16	102	42	08		PO	W
LV27	18	13	51	102	41	46		PO	W
LV28	18	23	38	102	33	54		PO	W
LV29	18	31	07	102	32	07		UF SS	C
Vietnam									
HT 1	10	31		106	25			nr	C
HT 2	10	31		106	25			nr	C
HT 3	10	05	51	105	52	39		DT	W
HT 4	10	05	51	105	52	39		nr	C
HT 5	10	05	51	105	52	39		nr	C

HT 6	10	11	01	105	56	08		DT	W
HT 7	10	20	56	105	56	24		CA	W
HT 8	10	23	32	106	18	06		IR	C
HT 9	10	54	15	106	34	19		IR	C
HT10	11	00	56	106	24	29		IR	C
HT11	11	00	56	106	24	29		nr	C
HT12	11	03	44	106	18	47		DT & IR	W & C
HT13	10	39	52	107	02	01		PO & DT	W
HT14	10	09	27	105	55	42	Loc Hou vil., Vinh		W
HT15	10	05	32	105	52	43	Long Phu vil., Vinh Long		W
HT16	10	24	26	106	06	00	Tieng Giang Prov.		W
HT17	10	33	35	106	25	15	Long An Prov.		C
HT18	10	33	35	106	25	15			C
HT19	10	33	35	106	25	15			C
CT 1	10	42	51	105	36	03		CA	W
CT 2	10	42	51	105	36	03		FL	C
CT 3	10	44	23	105	37	27	Tan Cong Sinh vil.	CA	W
CT 4	10	43	11	105	38	41	Phu Cuong	PO	W
CT 5	10	45	06	105	32	43		CA	W
CT 6	10	23	08	105	44	05	Binh Hong Trung	CA	W
CT 7	10	20	13	105	47	27	My Hup	CA	W
CT 8	10	19	33	105	48	41		CA	W
CT11	9	54	36	105	42	23	Thank Xuan	CA	W
CT12	9	54	05	105	41	18	do	IR	C
CT13	10	00	25	105	45	31	Hung Lo Ward	PO	W
CT14	10	00	35	105	45	35	Xuan Khanh Ward	CA	W
CT15	10	01	12	105	45	31			
CT18	10	24	26	106	06	00		PO	W
CT19	10	33	35	106	25	15		nr	C
CT20	10	33	35	106	25	15		nr	C
CT21	10	33	35	106	25	15		nr	C
Cambodia									
CB 1	nr			nr			At Mocbai immigration	DT	W
CB 2	11	04	07	106	09	06		PO	W & C
CB 4	11	08	36	105	29	24		CA	W
CB 5	11	33	06	104	50	32		PO	W & C
CB 6	11	32	00	104	49	27		DT	W & C
CB 7	11	31	42	104	48	06		PO	W & C
CB 8	11	32	50	104	50	16		DT	W
CB10	11	36	24	104	52	14		PO	W
CB11	11	14	37	105	19	23		PO	C
Malaysia									
MK 1	5	42	07	102	32	23		DT	W
MK 2	5	40	59	102	38	24		WD	W
MK 3	6	09	20	102	10	37		DT	W
MK 4	6	11	53	102	26	30		DT	W
MK 5	6	08	14	102	09	01		DT	W
MK 6	6	01	22	102	08	11		DT	W
MK 7	6	02	48	102	12	59		WD	W
Thailand									
CP38	14	41	18	100	27	41		DT	W & C
CP39	15	35	03	100	33	42		IR	C
CP40	15	35	03	100	33	50		IR	C

CP41	16	09	38	100	37	29	DT	W
CP42	16	49	25	100	25	37	DT	W
CP43	16	49	57	100	21	46	DT	W & C
CP44	15	13	08	100	12	30	CA	W
CP45	14	30	27	100	31	34	CA	W & C
CP46	14	29	49	100	31	48	CA	W
CP51	14	00	09	101	23	10	DT	W & C
NN59	16	49	39	99	47	33	DT	W & C
NN60	16	43	51	99	40	44	CA	W & C
NN61	16	00	13	99	47	59	PO	W
NE89	14	26	12	100	58	00	PO	W
NE90	14	34	57	101	00	32	DT	W
NE91	17	42	48	102	46	46	IR	C
NE92	17	28	36	102	47	44	DT	W & C
NE93	17	11	30	102	56	06	IR	C
NE94	17	01	40	102	54	22	nr	C
NE95	16	57	44	102	55	36	DT	W
NE96	16	21	46	102	48	18	DT	W
NE97	16	22	05	102	51	41	PO	W
NE98	15	50	04	102	36	47	IR	C
NE99	14	50	59	101	38	43	RF & GS	C

Latitude and Longitude data were taken by Global Positioning System (Sony IPS360).
Village name described was based upon interviews to farmer.
Topo.: Topography of land. RA; rainfed terraced, IR; irrigated lowland, CA; fringe of canal, PO; fringe or center of pond, DT; Ditch, WD; weedy type invading paddy field. GS and SS mean gentle and steep slopes, respectively.
Type: Wild (W) or Cultivated (C).
nr: No record.

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