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DISTRIBUTION OF EDIBLES WILD TARO (AROID PLANT) ON THE DIFFERENT ALTITUDE (SHOUTERN SLOPE OF WONOGIRI AND PACITAN)

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ABSTRACT

On the dry region of Wonogiri Regency and Pacitan Regency, in the Central Java and East Java Province's border of Indonesia, there is a potential group of plant which is still disguise from the researcher's attention. These wild edible tuberous plant, were actually have potential source of carbohydrate as an alternative to rice or corn inside the forest system or agro-forestry system. Their minimum maintenance, adaptability to drought and shading make them a potential plant as the staple food for the local people residing inside or in the forest's buffer zone. Wild taro (*Aracaceae* family) existence in the forest system or agro-forestry might increase the economic sustainability of forest. Using a Randomized block design method on the 5 plots sample located on the Northern slope of Wonogiri dry-land, the density and distribution type of wild taro and taro-like plants were surveyed. There were six genus of wild tuberous plant with 12 identified species and several endemic species identified. *Xantosoma* sp has the highest population, and generally the aroid plants have clumped distribution. Current situation of economical importance of other commodity and relationship with human agricultural activities may vary the distribution of Taro.

Keywords: Edible wild taro, distribution, altitude

INTRODUCTION

The adaptability of plant is mainly determined by its ability to complete its life cycle in many different environments (Begon *et al*., 2006). Hence, climate, soil condition, plants, animal, and human, influence the distribution and behaviors of organism. Further each organism has their own specific reproduction ability within the life cycle, while reproduction ability under environmental pressure determines the persistence of the plant in the certain environment. However the growth of certain species population is not unlimited, because unlike the mobile animal, plants are unable to avoid the competition with others (Vance and Nevai, 2006).

Begon *et al*. (2006) stated that several factors might influence the variations on plant, which are : genetic mutation, cross pollination, geographical isolation, and morphological changes associated with heteroblastic development related with temperature and the irradiation period. Further, in many cases of taro and yam, the adaptation mostly related with the man preference of palatable species or variation (Onwueme, 1999)

There are many kinds of tuberous crops and taros in the tropics, some of the species are utilized as dietary staples. However, not much scientific research on these crops performed including the field of ecology, cultivation, post-harvest and biochemistry. With a proper research and development, it is possible that those crops may be helpful in solving the world food shortage that is anticipated for the twenty-first century due to increases in the world population (Uritani, 1999).

Taro and Taro-like plants belong to the group of aroid plant, which the vast majority of the genera occur in the tropics. Members of the family are highly diverse in life forms, leaf morphology, and inflorescence characteristics. Life forms range from submerged or free-floating aquatics to terrestrial (sometimes tuberous). Some of them are epiphytic or hemi-epiphytic plants or climbers. Leaves range from simple and entire to compound and highly divided, and may be basal or produced from an aerial stem. The family is best characterized by its distinctive inflorescence, a spadix with bisexual or unisexual (sometimes with sterile region) and subtended by a solitary spathe on a long or very short peduncle (Wang, 1983).

The most well known species belongs to *Aracaceae* family is Taro (*Colocasia esculenta* L.) because it's edible and palatable corms. However there are so many plants which are similar to this species and uncultivated as wild plants and belong to another genus such as :*Amorphopalus, Xanthosoma, Alocasia, Canna* and *Maranta.* Almost all of those genuses produce the fleshy and starchy corm, but not all of them are palatable to man (Horton, 1988).

Most of the dry and mountainous land adapts the dry land farming system which is use **mix cropping** system with multi purpose trees species to provide the income and lifehood for the farmer. Mix cropping or **Kebun** is the closest or the most resemble forest in heavily modified rural and forest border landscape (Marjokorpi and Ruokolainen, 2003 ; van Noordwijk *et al*., 2007). Further, according to Werner (1993) **kebun** is also the important refuges for forest trees outside natural forest while in the same time also provide the income for the farmer without logging the trees. Hence it is important to maintain the sustainability of this landscape type because it provides both environmental and ecological services.

The existence of food crop (carbohydrate source) in the mix cropping or **kebun** is essential to maintain its sustainability because it provides the staple food to the indigenous society who depend their live hood on the long time investment trees species. In the future, it is possible to develop the Taro and Taro-like plant to be the important crop under the trees in agro-forestry system. The information about site ecology facts is important to ecologist, conservation biologist and government planner to understand how the community of organisms is structured, especially for the potential of edible plants on the tree shades. Such information of population and distribution is valuable for develop the crop plants in an aforestation area which dominated by trees species. Based on previous assumptions the objectives which we investigate on this research are: determining the population, variation and the distribution pattern of Taro plant and Taro-like plant in the dry-land mix cropping system to provide the basic information for the ecology of this group.

MATERIALS AND METHODS

The study was conducted in several areas of Wonogiri Regency, and Pacitan Regency Central Java and East Java Province of Indonesia from April to June 2006 as a part of economic and ecological evaluation on dry-land agriculture system sustainability study. Wonogiri and Pacitan regency is neighboring regencies located on the border of Central Java and East Java province with rocky and hilly area due to its location on the Sewu highlands. The climate of the research site is between C to D (moderately dry) according to Schmidt and Fergusson climate classification with annual precipitation 750 – 1000 mm and 5 to 6 wet months, the driest months are July to September while the temperature is ranging between 24 – 32 ºC. Shallow top soil with lime stone is dominated the soil makes common agriculture practices are not favorable.

The study site was a home garden and reforestation area owes by people, society and government plantation forest. Thousands of trees such as teak (*Tectona grandis*), mahagony (*Sweitenia mahagony*), **Sengon** (*Albizia falcata*), **Lamtoro** (*Leucaena glauca)* create a multilayer trees and enough litter on the soil to protect it from the erosion, also provide nutrients for the soil. Contrast with reports of the over exploitation of forest resources across the country, farmers in this area have managed to convert arid and seemingly barren land into a flourishing ecosystem. Trees are thriving among the limestone cliffs and shallow caves of these hilly areas. The big trees and small trees are shoehorned in among rocks. The concept of reforestation seems to be well applied in this area while multi purpose trees and edible food crop are integrated in this system.

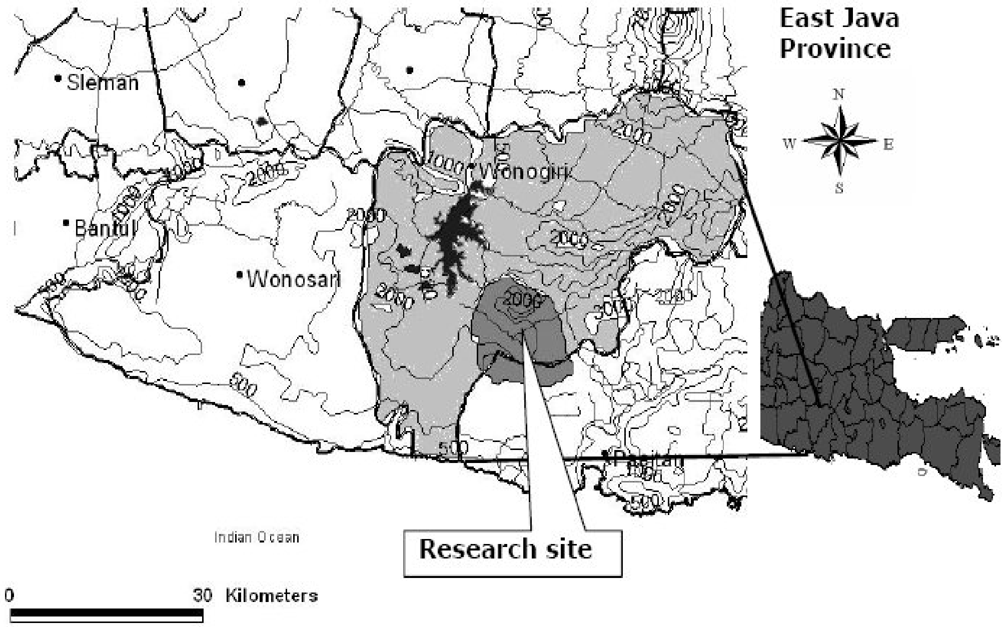

Figure 1. The map showing the location of study site

Experimental Design

Aroid plants was studied on their number of occurrence and distribution pattern on three replicated systematic plots (each 20 x 20 m) within 5 levels of altitude 100, 300, 500, 700 and 1000 m above sea level (asl..) respectively. The objective of this research is to investigate if the different altitude had an influence on the distribution and the number of occurrence of the Aroid plants. Analysis of variance was conducted from a randomized block design with the altitude is the treatment level. These plots were set systematically with three replications each and least significant test (LSD) was conducted in case significance of the F test at $p < 0.05$

Several determinations were conducted to each specimen of aroid plants such as genus and species based on Mountain Flora of Java (van Steenis, 2007). However, considering the small number of specimen collected from the sampling, and Aroid species sometimes found densely in specific places, we rather tested our data among the edible tuberous plants group only and not compare it with other plants. The Aroid plant density index were calculated, while the distribution pattern index were determined using the Morisita's Index (*Id*) (Morisita, 1959; Cressie, 1993,). For uniform distribution of the genus, *Id* increases with the size of the cells to reach the value 1. If it is randomly distribute *id* index is equal to 1 or around a mean value of 1 and when clusters are present, *Id* becomes greater than 1.

RESULTS AND DISCUSSION

The Potential Environment for Suitable Growth and Development of Edible Aroids

The collected aroid plants are varying significantly between the altitudes, based on the analysis of variance on the number of occurrence, the altitude of 100m and 300m asl.. have the greatest number of aroid plants collected and the altitude 1000m asl., had the lowest number of Aroid plants (Table 1).

From the number of occurrence on various altitudes, most of the genus, species and its variety flourished on the altitude of 100 – 300 m asl. and there is no significant difference in its number on those altitudes. Six genus of wild taro

(Aracaceae family) were found in this range, *Colocasia* has the highest number compare to the other Genus, followed by *Xanthosoma, Canna, Maranta* and *Amorphopallus* respectively. However, the number continuously decline on the altitude of 500 – 1000 m asl (Figure 2).

Table 1. Comparison of the aroid plants number of occurrence per plot on different altitude

Altitude (m)	Number of Occurence
100	62.00 c
300	59.83 c
500	37.33 b
700	21.16 a
1000	9.00 a

Remarks: The altitude level were highly significant in the number of occurrence on Aroid plants at a level of 1% probability (p<0,01) with F=33.7525**. Numbers followed by the same letter in the last row are not significantly different at p<0.05 (LSD test)

The Figure 2 shows only three Genus of aroid plants still survive in the altitude of 700 m to 1000 m asl.. which are : Xanthosoma, Canna and Colocasia, while Amorphopalus, Marantha and Alocasia is not existed on that altitude.

Moreover, the altitude 100m and 300m asl.. is highly supportive to most Aroids species, especially from genus Colocasia. The result also shows that it is best to establish Taro plantation from genus Colocasia that takes the advantage. Taro in its natural state is a semi-aquatic tropical herb, and can easily become weedy in disturbed or managed habitats that are warm, wet and open to the sun (Matthews, 2004).

Contrasting the Colocasia genus, Amorphophallus can only be found until 300m asl.(Figure 3). This may comply that the majority of Amorphophallus species seem to be pioneers in disturbed vegetations. Many are found at forest margins, in open savannah forests, on (steep) slopes, in disturbed parts of primary forest, and sometimes in very exposed parts in limestone karsts areas. Relatively few species are known to live in dense forest.

Aroids has become neglected crops and wildly grows in many international community, however it is locally important as staples or reserve foods used in times of need. In many farm site or garden, they are grown or left to grow in poor soil without the management. On the other hand, this group is efficient food plants and if marginal land is to be brought into production to support burgeoning population, the potential of these crops is worth to develop (Lebot *et al.,* 2005). Moreover, according to Long *et al.* (2003), this group is under threat of human activities such asl..and opening for agriculture, road building and tourism development in their natural habitats.

In some regions of Asia and the Pacific, more productive root crops, such as cassava (*Manihot esculenta,* Crantz) and sweet potato (*Ipomoea batatas* (L.) Lam.), are gradually replacing taro (Caillon *et al*., 2005). Even though this group is mostly found in low land agriculture site, but there is a disappearing trends because it is replace by more productive plants. However, in high and hinterland on pacific islands, this group is commonly use, and mostly for staples, moreover this group appear to more shades tolerance then most other crop, which make this group is favorable for agro-forestry system (Onwueme, 1999).

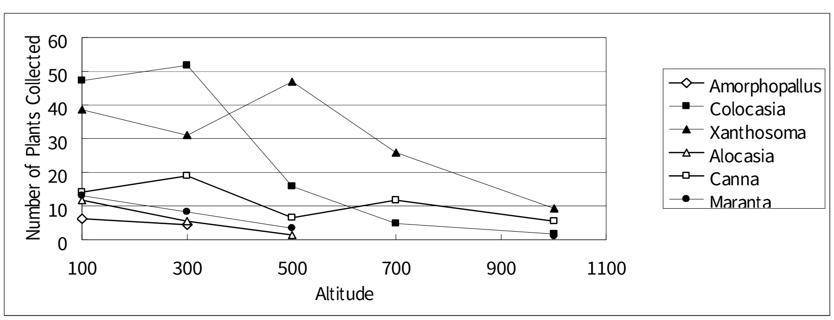

Figure 2. The Number of collected plants of Aroid plants in Slope of Wonogiri and Pacitan dryland. Identification for the Aroid Genus were taken from Van Steenis (1972)

The Species Identified in Various Altitude

A total of 14 species of Araceae was found. Most belonged to Colocasia (3 species) or Amorphopalus (3 species), while Canna, Alocasia, Xanthosoma and Maranta each had two species. The mean number of species per plot was 2 (SE = 1.2). Species richness was higher on the low altitude and the low on higher altitude. Hence, the differences between the altitudes were significant (Table 2).

On the range of 100 – 300m asl., genus of Colocasia dominated with species of *Colocasia esculenta* L. while the other species is wild type of *Colocasia* (*Colocasia spp.*) which commonly use for ornamental plants. Hence the edible *Colocasia* tuber was only found on the range of 100 – 500 m asl. because on the higher altitude this plant is unable to produce the tuber. Within the range of 500 – 1000 m asl.. local people use only the leaves and petiole as vegetables dietary (Matthews, 2004).

The *Amorphopalus* mostly distributed only on the low altitude (ranging from 100 – 300 m asl..) with three identified species which are: local name **iles-iles** or *Amorphopalus variabilis, Amorphopalus campanulatus,* and ***Porang*** or *Amorphopalus onchopilus,* they are commonly edible species for local people. Still in the same altitude range, genus of *Maranta* was found in three species, *Maranta arundinacea*, *Maranta amplicolia* and *Maranta linearis* (Table 3). However, from those three species, *Maranta arundinacea* is the most populated species. Moreover, *Maranta arundinacea* is mostly distributed on the low land (100 – 300 m asl.) and decreased with the increase of altitude (Indonesian Department of Agriculture, 2008). On the altitude of 500 m asl., the genus there are only 6 species identified on this region, which are: *C. gigantea, C. esculenta, X. violaceum, A.. acuminata, Canna indica,* and *M. Arundinacea.* In this level of altitude, there is already significantly less species identified compare to 100 – 300 m asl. Further on 700 m and 1000 m shows significantly reduced on species identified.

From the variance analysis on Table 2, shows that there is a significant decrease on species identified with the increase of altitude. The more species identified on 100 m and 300 m asl., while the fewest is on 700 m and 1000 m asl. (Table 2). This phenomenon occurred because there is actually a division possible in aroid species found in strongly seasonal climates (e.g. most of Africa, India, Thailand, Indochina, Java), and those found in more wet climates (e.g. Sumatra, Borneo). The division also found in the altitude range between low land and highland (Hetterscheid and Ittenbach, 1996).

Table 2. Number of species identified on several altitudes

Altitude (m)	Number of Identified Species
100	4.3 c
300	4.0 bc
500	3.2 b
700	1.6 a
1000	1.3 a

Remarks: The altitude level were significant in the number of Species identified of Aroid plants at the level of 5% probability (0,01 < p < 0.05) with F = 5.4754*. Numbers followed by the same letter in the last row are not significantly different at p<0.05 (LSD test)

Many species in Java may be found in soils on granite bedrock, but more often in limestone areas. The altitudinal range varies from sea level to 1000 meters. Flowering starts mostly just prior to the onset of the rains. In Asia flowering specimens that are effectively pollinated will not develop leaves anymore that season (except for three "evergreen" species), but the African species will always develop leaves in each growing season, whether flowering or not, while highland species, limited to genus of Colocasia, Amorphopalus and sometimes Canna (Hetterscheid and Ittenbach, 1996).

From the identified species (Table 3) shows that 100 – 300 m asl., is the preferable condition for many aroid species, while 500 m above is not a preferable condition for many aroid plants. However, Indonesian Department of Agriculture (2008) classifies that Taro can be planted from 350 until more than 700 m asl. (Table 4). However, as cassava export is in top position (Indonesia Department of Agriculture, 2008), this may also discourage people to plant Taro species for economical reason, but in the shading condition like in agro-forestry system only Taro groups can be cultivated as staple food.

Density and Distribution of Aroid Plant (Morisita Index)

To measured the contribution of each genus to a community (Vargas *et al*., 2004), the density of each genus should be measured to expresses the area occupied by a certain genus per unit area. From the measurement shows the Xanthosoma has the highest density followed by Colocasia, Canna, Alocasia, Amporphopalus and Marantha, respectively.

Relationships between species density, soil and water factors may be expected. At least for major soil nutrients, such as nitrogen, phosphorus and potassium on this area might express the various plant densities. The soil assessment on these region (Nobe, 1974) shows the fertility level vary from low to moderate, which determined by Nitrogen, Ion exchange capacity, organic carbon, total Phosphor, total Potassium and Sulfate. The soil fertility also distributed clumpy associated with organic matter and soil water content which also explain the clumpy distribution of aroid plants on the study area (Table 5).

Table 3. The identified species on several altitude

Genus	Species				
	100 m	**300 m**	**500 m**	**700 m**	**1000 m**
Amorphopallus	*A. onchopilus* *A. campanulatus*	*A. variabilis* *A. onchopilus* *A. campanulatus*	-	-	-
Colocasia	*C. esculenta* *C. bicolor* *C. gigantea*	*C. esculenta* *C. bicolor*	*C. gigantea* *C. esculenta*	*C. esculenta* *C. bicolor*	*C. bicolor*
Xanthosoma	*X. violaceum* *X. sagittiofolium*	*X. violaceum* *X. sagittiofolium*	*X. violaceum*	*X. violaceum*	*X. violaceum*
Alocasia	*A.. acuminata*	*A.. macrorhiza* *A.. acuminata*	*A.. acuminata*	-	-
Canna	*C. Edulis*	*C. Edulis* *C. indica*	*C. indica*	*C. edulis*	*C. indica*
Maranta	*M. arundinaceae*	*M. arundinaceae* *M. Linearis*	*M. arundinaceae*	-	-

Table 4. Classification of agricultural plants according to agro-ecosystem of highland

Elevation (m) asl.	Wet climate	Dry climate
Medium Terrain 350 - 700		
Beans	Soy bean, peanuts, green beans, Arabic beans, mukuna	Soy bean, green beans, Arabic beans, cowpea, mukuna
Cereals	Paddy, corn, sorghum	Wheat, sorghum
Tubers	Sweet potato, cassava, *Colocasia* taro, *Amorphophallus*,taro.	Sweet potato, cassava
High Terrain > 700		
Beans	Soy beans, red beans, French beans, mukuna	
Cereals	Paddy, corn, sorghum	Wheat, sorgum
Tubers	Seet potato, cassava, *Amorphophallus,* taro	Sweet potato, cassava, *Amorphophallus,* taro

Source: Indonesian Department of Agriculture (2006)

Table 5. Density and distribution pattern

Genus	Density / (20 x 20m) plot	Distribution Pattern	Distribution Value
Amorphophalus	0.09	1.07	Random
Colocasia	1.22	4.80	Clumped
Xanthosoma	2.22	4.95	Clumped
Alocasia	0.16	0.05	Uniform
Canna	0.99	4.70	Clumped
Maranta	0.34	2.50	Clumped

Differences among species in their abilities to exploit limiting resources affect the coexistence of species (Tilman, 1982). Since some plant species have special adaptations to low nitrogen availability and others to low phosphorus availability, the type of nutrient limitation may affect species composition and richness through its effect on productivity (Venterink *et al*., 2003). The species mosaic theory states that the mechanism that could help maintain high plant species density involves differentiation in the use of various materials, such as nitrogen, phosphorus, potassium, calcium, and so on; according to this argument, each plant species has its own peculiar set of requirements (Pianka, 1994).

From the table 5 shows that, the only uniform distribution of the aroid plants found on Alocasia which probably shows the cultivated activity by human to this genus. However, other genus shows clumped and random distribution, mainly because their vegetative reproduction and associated with special requirement such as light intensity and soil humidity.

Further the clumpy aroid plant distribution character related mainly with the vegetative propagation pattern of the plants and the ability of plants to harvest the nutrient and adapt to the specific condition. By understanding the distribution pattern in the nature, will provide the plan and the management of specific planning for environment management in this area. Although many scientists stated several environmental factors concerning the plant distribution but the most consistent pattern of species distribution on the tropical forest worldwide is a rainfall association with topography which drive variation in soil water availability and many derivatives factor such as soil pH and Nutrient (Bettina *et al*, 2007). Moreover seedling drought sensitivity might be the internal factor of distribution variation among the aroid plants while the external important factor such as predation and herbivores activities might also plays the important role of the variation.

CONCLUSIONS AND SUGGESTION

Several phenomena of wild taro/aroid plants in dry highland Wonogiri are confirmed. Aroid plants are varying significantly with the change of altitude. The altitude of 100 – 300 m above sea level is the favorable condition for aroid growth, which six genus and fourteen species found. Further, with the increase of altitude the less favorable condition for aroid growth. The same trend also occurs on the species number, which significantly reduce with the increase of altitude.

Without the cultivation activity, the genus Xanthosoma and Colocasia has the highest density which shows their higher ability to adapt on the certain condition, while Amorphopalus shows the lowest. Most of the aroid plants distribution in this area is clumped, which explain the main influence of vegetative propagation dominance of this group.

The existing research on this area development is mainly about forestry and hardwood species which takes at least five years to harvest. However such trees and hardwood species only, cannot be used effectively for community sustainability and food safety program. Under such circumstances we suggest integrating the aroid plants within the newly forest development program in Wonogiri area using GIS application on determine the exact location of potential development area.

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Appendix The figures of wild taro found in the research site

Xanthosoma sagittiofolium

Marantha arundinacea

Amarphopalus campanulatus

Colocasia esculenta

Canna edulis

Allocasia acuminata