THE PROGRESS REPORT OF THE 2000 AND 2001 SURVEY OF THE RESEARCH PROJECT "SOCIAL HOMEOSTASIS OF SMALL ISLANDS IN AN ISLAND-ZONE"

ISLANDS IN SOUTHERN JAPAN

Edited by Shinichi NODA

はじめに

Preface

We are pleased to announce the publication of the official report of the research project " Social Homeostasis of Small Islands in an Island-Zone" conducted by the Kagoshima University Research Center for the Pacific Islands (KURCPI) in the years 2000 and 2001.

This multi-disciplinary research project was started in 1999 as a three-year project by the four members of the KURCPI with the collaboration of more than forty researchers from other faculties of Kagoshima University. The term " homeostasis" describes, as its biological origin suggests, the actual and potential ways in which the stability, not necessarily static but also dynamic, and the sustainability of a society are achieved, without forfeiting its interaction and inter-dependency with the outside world. The goal of the project is to obtain an understanding of how social homeostasis may be achieved in a society on a small island. The term " island-zone" indicates that an island, though insulated by the sea, needs to be understood in the context of a group of islands, where networks of people, things, and information are formed and interaction between islands take place.

As the main research fields for the project, we chose the Satsunan Islands in Southern Japan and the island-zone of Yap in Micronesia. Both are island-zones consisting of a group of small islands with biological, social, and cultural relationships among themselves, and they share common difficulties, typical of small islands. The main difference between them is that the Satsunan Islands are a peripheral part of one of the most developed economies in the world, whereas the island-zone of Yap belongs to a modest island nation. This contrast enabled us to make a comparative approach to the studies on small islands.

The present report represents results of the research project in its second and third years. It consists of two parts, each forming an individual volume in the KURCPI Occasional Paper Series. Part One, in volume 38, is a collection of papers which involve the researches carried out in Japan in 2000 and 2001. These researches concern a variety of topics relating to island-zones and small islands in Southern Japan. Part Two, in volume 39, contains papers based on the researches carried out in 2000 and 2001 in Yap, Micronesia, including the research conducted by the Survey Party in Ulithi Atoll in 2001. The drafts of the papers in Part Two were reviewed by the Council of Tamol (traditional chiefs in the Outer Islands of Yap) to ensure accuracy before publication. Reflecting our multi-disciplinary approach, both Part One and Two are subdivided into sections on human activities, physical geography, and people-nature interactions. Each section involves, (1) history, society, culture, education, tourism, and human movement, (2) geology, geography, and ecology, and (3) agriculture, fisheries, public health, and the impact of natural disasters.

We hope this two-volume report will bring benefits to the people of the local communities with which the research was concerned. We also hope this provides us with an insight into the present conditions of the two island zones in the Northwestern Pacific and that it will further encourage studies on the small islands in this part of the world, so that researchers can exchange ideas and information and develop general theories on small islands in the future.

Toru AOYAMA
Shinichi NODA
Editor
KURCPI

Contents

SECTION ONE: HUMAN ACTIVITY

SECTION TWO: PHYSICAL GEOGRAPHY

SECTION THREE: PEOPLE-NATURE INTERACTIONS

島嶼地区における自殺の現状と推移
－自殺を予防する方法の確立を目指して－

要　　旨

キーワード：

EPIDEMIOLOGICAL STUDY OF SUICIDE IN THE ISLANDS OF KAGOSHIMA PREFECTURE

Mamoru OGATA, Yoshiyuki ORIHARA, Kazutoshi AGO and Mihoko AGO

Abstract

Cases of suicide in the islands of Kagoshima Prefecture for the last three years (1999-2001) were investigated. The total number was 165. Average annual suicide rate (per 100,000 population) was estimated to be 29.0. Suicide rate in the male (46.5) was larger than that in the female (13.0; p<0.0001). Suicide rate in the male in sixties was larger than that in 1989-1991 (p=0.0002). As a background of suicide, pessimistic and economical reasons of male suicides were increased (p<0.0001). Recent business depression might have lead to increase male suicidal number. Single or two-person households and past suicide attempt were considered to be risk factors for suicide. Protective activities by government, society and family should be developed for reducing suicidal number.

Key words: Islands of Kagoshima Prefecture, Protective activities by society, Suicide

緒　　言

方　法

結　果

1. 自殺者数，自殺率

2. 性別，年齢別の検討

p

Fig

p

Fig.1. Suicide rate in the islands of Kagoshima Prefecture.

３．月別，曜日別，時間帯別の検討

４．自殺手段

Table

Table 1. Methods of committing suicide in the islands

	Male		Female	
	1989-1991	1999-2001	1989-1991	1999-2001
縊死 Hanging	69%	63%	56%	48%
入水 Submersion	2	6	24	18
服毒 Poisoning	11	13	6	21
排ガス Vehicle exhaust gas	4	4	2	0
飛び降り Jumping from height	7	6	2	10
焼身 Burning	4	6	4	0
その他 Others	3	2	6	3

５．自殺の背景

Table

p

Table 2. Background or motive of suicide in the islands

	Male		Female	
	1989-1991	1999-2001	1989-1991	1999-2001
病苦 Pain of sickness	63%	50%	70%	58%
厭世 Pessimistic	5	21*	6	22
経済的理由 Economical	5	20*	3	2
対人関係 Personal relationship	14	8	15	18
その他 Others	13	1	6	0

*: $p < 0.0001$

６．自殺企図経験者の割合

７．家族構成の検討

考　察

文　献

⑷　⑵

⑸

奄美大島における歴史的文化財を活用した観光開発の可能性

要　　旨

キーワード：

AMAMI OSHIMA'S POTENTIAL OF TOURISM DEVELOPMENT BY MAKING EFFICIENT USE OF ITS HISTORICAL HERITAGES

Eiji Nitta

Abstract

Generally island has some suffocating factors for tourism. However Amami Oshima has many cultural heritages besides natural ones that have attracted tourists. Based on the cultural heritage resource management studies, Amami Oshima has a big potential of island tourism development by making efficient use of its archaeological and historical heritages. For example, two of the cultural resources in Amami should be focused. One is the ancient maritime trade route for commodities such as the trade ceramics and the south sea shells that connected Amami and other islands. Another is the museum network in Amami Oshima. Amami Oshima should aim for the multiple tourism composed of nature, history, culture and experience.

Key words: Amami Oshima, Island tourism, Tourism development, Historical heritage, Cultural heritage

1．島嶼部の観光空間構造からの分析

(1)

Sun

Sand　　　　Sea

(2)
(1)

(3)

(4)

(5)

(6)

２．従来の観光開発計画

入域客および入域観光客数（推計）

年	海路	空路	入域観光客数
1996 年	136,723	415,067	386,790
1997 年	135,507	440,714	397,340
1998 年	132,002	443,866	404,205
1999 年	131,995	435,149	391,929
2000 年	130,022	424,823	362,165

発地別

東京

年	海路	空路	合計
1993 年	2,940	1,202	4,142
1994 年	2,882	35,934	38,816
1995 年	1,264	35,876	37,140
1996 年	1,395	33,175	34,570
1997 年	1,958	36,446	38,404
1998 年	1,621	35,500	37,121
1999 年	2,148	32,854	35,002
2000 年	1,967	31,898	33,865
2000 年割合	5.8%	94.2%	

阪神

年	海路	空路	入域観光客数
1996 年	8,868	50,977	59,845
1997 年	9,193	61,846	71,039
1998 年	8,386	57,776	66,162
1999 年	8,514	53,505	62,019
2000 年	6,827	49,715	56,542
2000 年割合	12.1%	87.9%	

鹿児島

年	海路	空路	合計
1996 年	91,591	297,982	389,573
1997 年	90,448	309,264	399,712
1998 年	86,904	320,484	407,388
1999 年	85,945	316,926	402,871
2000 年	85,164	317,801	402,965
2000 年割合	21.1%	78.9%	

合計

年	海路	空路	合計
1993 年			543,335
1994 年			549,019
1995 年			554,162
1996 年	136,723	415,067	551,790
1997 年	135,507	440,714	576,221
1998 年	132,002	443,866	575,868
1999 年	131,995	435,149	567,144
2000 年	130,022	424,823	554,845
2000 年割合	23.4%	76.6%	

(1)

３．歴史的文化遺産を活用した観光開発の可能性：文化財資源学の視点から

文　　献

屋久島栗生の民家及び集落の現状と町づくりへの展望

要　　旨

キーワード：

ON THE PRESENT CONDITION OF THE RURAL HOUSES AND THE SETTLEMENT OF KURINO, YAKUSHIMA ISLAND AND THE VIEW FOR ITS COMMUNITY DEVELOPMENT

Mitsuyoshi Tsuchida

Abstract

Since Kurino on Yaku Island has been an important port from Edo period, Tsuguchi Guard Station of Satuma- Han has been established, and the landscape of the original fishing village has been preserved. In this paper, two rural houses of Edo period were selected from the existing large-scale fisherman's houses as the research subjects. The features of these two buildings were described, and the significant value of the two houses as part of the scene was stated. In the end, a community development with emphasis on the history was proposed.

Key words: Landscape of Kurino, Fishing settlement, Fisherman's house, Tsuguchi Guard Station, Producing district of dried bonito flakes

１．栗生の集落

２．栗生の民家
１） 岡留重一氏住宅

２）岡留純矩氏住宅

３．町づくりへの提言

１） 遺構を調査する

２） 歴史を尊重し，町づくりに生かす

３） 他の地域とのネットワーク

４） 伝統的建造物群保存地区にする

南西諸島島嶼社会における女性霊性の民俗学的研究

<center>要　　旨</center>

キーワード

A FOLKLORE STUDY OF THE WOMEN᾽S SPIRITUAL PARTS ON AN ISLAND᾽S SOCIETY OF THE SOUTHWEST ISLANDS, JAPAN

Aki TOKUMARU

Abstract

This study aimed at explain the actual conditions of the systems concerned with "Tukasa" - the female priests in the southwest islands, japan and study the expressions women᾽s spiritual parts and functions in respective age-grade based on Tukasa᾽s oral traditions and "Ugan-note".

Key words: Tukasa, Ugan-note, Systems of the female priests, Women᾽s spiritual parts, Age-grade system

女性霊性と女性司祭

伊良部島のツカサ制度

池間添（ナカムラ，上位）	前里添（ホンムラ，下位）
アニンマ（後見人，3名）	アニンマ（同左）
フンマ（最高位のツカサ，1名）	フンマ（同左）
カカランマ（フンマの補佐役，1名）	カカランマ（同左）
ナカンマ（フンマの使い，荷物持1名	ナカンマ（同左）

N

月日（旧）	行　事　名	ニガイの目的
1月24日	マビトダミニガイ	集落内健康安全の願い
1月26日	カリウスダミーニガイ	航海安全の願い
1月28日	ウホユダミニガイ	豊作・豊年の願い
1月29日	ツイタチニガイ	毎月1日に行う願い
2月 4日	マビトダミカサンバン	重ねてウフユを求める願い
2月 7日	カリウスダミカサンバン	重ねて航海安全を求める願い
2月 9日	イドニガイ	井戸の願い
2月11日	ムシヌヌンニガイ	畑から虫を採って海に流す願い
2月13日	ハマニガイ	豚を屠殺し頭を海に献ずる願い
2月25日	セイトガンニガイ	小学校・中学校の安全を祈願する願い
3月 5日	スマカリュウニガイ	旅人の健康を祈願する願い
3月 7日	オヨギニガイ	水泳の安全の願い
3月15日	タビカリュウニガイ	不明
3月19日	ウホユダミヌカサンバン	豊作・豊年の重ねた願い
3月23日	マニヌバンムツ	赤豆・黒豆の豊作の願い
3月24日	ムズヌバンムツ	麦の豊作の願い
3月27日	カサヌバンニガイ	疱瘡が軽く済むことを祈願する願い
4月15日	サンバシニガイ	桟橋の願い
5月 4日	ハアリイヌフシアキ	ハーリー祭（船競争）安全祈願の願い
5月14日	イモノバンムツ	芋の豊作の願い
5月20日	タイリョニガイ	大漁の願い
5月24日	キビニガイ	黍の豊作の願い

5月26日	ハナヒシダミニガイ	風邪を除ける願い
6月16日	アワビニウイ	粟の豊作の願い（３日間一睡もせず願う）
8月 9日	ウホンマクライアガイニガイ	ホンマの位が高まったのを祝う願い
8月22日	ウホンマダツナウイニガイ	本村・中村のホンマ共同で行う願い
8月26日	バンプトツニガイ	願降ろしの願い
9月 2日	ミヤクズツアラビ	男性の祭り
9月16日	ユウクイ	女性の祭り
10月 1日	ヒヤズニガイ	伊良部のヒャーズ（ウガンジョ）の願い
10月10日	ヒヤアズニガイ	ヒユイトリ（日取り取り）
10月16日	イモビニユイウサギ	芋のミキを捧げる願い
10月22日	ヒヤアズ	願い立て
10月 中	マキニガイ	牧の願い
11月 7日	ダツナウイニガイ	今年の願いの成就を感謝する願い
11月11日	ハマニガイ	春のハマニガイの成就を感謝する願い
11月12日	トマイニガイ	出稼ぎで島外に泊まる男性を守る願い
12月16日	カエルニガ	司が草を被り杖をついて家々を巡りの悪いものを追い出す願い
12月22日	イドニガイ	井戸の願いの成就を感謝する願い

1	フンマはシマから出てはいけない。
2	フンマはシマの外を意識的に見てはいけない。クバガサを被る。
3	ツカサ以外に仕事をしてはいけない（家事労働を除く）。
4	毎朝３時，ウハルズ御嶽に行き御嶽と東方を遙拝する。
5	フンマが外を歩く時には必ず両手の平を上に向けて歩く。
6	頭上運搬をしてはいけない。タオル等を掛けてもいけない。
7	必ず簪をさす（キダヌキー＝フンマ，銀制簪＝下位のツカサ）。
8	髪を切ってはいけない。
9	フンマは外を歩く時は白い服を着る。赤いものを身に付けてはいけない。
10	フンマの袖に他人がふれてはいけない。
11	雨具を身に着けてはいけない。
12	結婚式，葬式，出産のあった家へ行ってはいけない。
13	フンマは一門墓には入らない（別に墓を作る）。
14	ツカサが６人揃わないと自動車には乗れない。
15	ツカサが揃ったら常にフンマ指示し，下位のツカサはそれに従う。下位のツカサはフンマの右を歩けない。
16	フンマの家はカミの家であるから，常に清浄にし，悪い言葉を使わない。
17	フンマが夫と性行為をした後は，身を清めた後，マウを拝む。

伊良部島における女性の年齢階梯と女性霊性に関わる社会的役割

幼年期	誕生 無経期	10日目までの死者はアクマとなる 漁船の船霊への毛髪提供 　（無経期少女の霊的資質による豊漁への期待） 　　　　　　　　　↓
青年期	初潮 婚姻 ユミサーイ 出産 育児	中止 （オナリの観念に基づく男性兄弟への霊的守護） （カミダーリー→ユタ・モノシリ）
主婦期		夫の漁船のニガインマ 　（夫婦関係を軸にした霊的守護の期待） マウ（個人・夫婦神）・火の神等イエの カミ，祖先の祭祀によるイエの守護
	47歳〜57歳	ユークインマ（10年間） 　マウによる予兆（夢見） ウハルズ御嶽ツカサ（共同体の司祭者） への就任（3年間） 　仕事からの引退（家事労働を除く） 　日常生活における禁忌の厳守 　アニンマからの指導 　ウハルズ御嶽の祭祀 　共同体におけるウガンの実施
老年期	閉経 死	アニンマ（ツカサの指導役）への就任（3年間） クライアガイニガイ（霊的な位の上昇） 　共同体の女性達の後見人的立場 一門墓（父系出自単位）とは別個に埋葬 　（フンマのみ）

小括

EVIDENCE OF SEASONAL AND GEOGRAPHICAL VARIATIONS IN *ZOANTHUS PACIFICUS* AND ITS ENDOSYMBIOTIC ZOOXANTHELLAE DUE TO ENVIRONMENTAL FACTORS

James D. REIMER, Shusuke ONO and Junzo TSUKAHARA

Abstract

Despite much progress, many questions regarding coral bleaching in cnidarians are still unanswered. One specific phenomenon that has received little attention thus far is the variability and change in zooxanthellae body types due to environmental changes. Our previous studies have shown that zooxanthellae are strongly affected by abnormal light and especially, abnormally high seawater temperatures. However, all previous research has been conducted in the lab, with samples from only one site. Confirmation of these hypotheses in the field from multiple sites would go a long way in helping solidify our previous theories, and shed light on other aspects of the cnidarian-zooxanthellae symbiosis.

To accomplish this samples of the encrusting anemone *Zoanthus pacificus* were collected each month from four field sites (Kokubu-Wakamiko (K), Sakurajima-Hakamagoshi (S), Yakushima-Kurio (Y), and Amami-Oshima-Kasari (A)). Immediately after sampling, endosymbiotic zooxanthellae were isolated from each sample and examined under a microscope using a hemocytometer, and classified by body type. % cover transect data was also collected. Initial (15 month results) show that the sites can be divided into Northern (K and S) and Southern (Y and A) Groups. The Northern Group shows little decrease in NZ during summer, but a significant drop in NZ during the winter months while the Southern Group displays an NZ decrease in hot summer months, and either no drop (A) or a slight drop (Y) in NZ during winter. (A) shows no drop in NZ ratios during winter, and (Y) shows a decrease in NZ (although not as dramatic as K or S). These results indicate that seawater minimum and maximum temperatures approach 17 and 30 , respectively, based on temperature readings taken from the field sites. This is supported by the transect data, which shows a marked decrease in % *Zoanthus* cover over winter at Y but not at A. Additionally, *Zoanthus* appears to be able to withstand short-term (up to 6 hours) intertidal temperatures ranging from 13 to 37 .

Key words: Zoanthid, Zooxanthellae, Body type, Temperature, *Zoanthus*, Bleaching, Seasonal variation

Introduction

Zoanthus and other cnidarians such as coral rely heavily upon endosymbiotic zooxanthellae as a source of energy. Even though the problem of coral bleaching (the expulsion and/or degradation of endosymbiotic zooxanthellae) has become a worldwide issue (GLYNN & D'CROZ, 1990; HOEGH-GULDBERG & SMITH, 1989), and many studies have been conducted on coral and zooxanthellae, there are still many unanswered questions. Previous studies in the lab on *Zoanthus* (REIMER et al. in review 2002) have shown that at 30 and 33 *Zoanthus'* normal zooxanthellae (NZ)

become less frequent than at normal temperatures (23), and the degraded zooxanthellae (DZ) form DDZ (dark degraded zooxanthellae) becomes more frequent. (For detailed explanations of zooxanthellae body types please see Figure 1, and TITLYANOV et al., 1996, and KUROKI & van WOESIK, 1999) There is also direct lab evidence of digestion of zooxanthellae by *Zoanthus* (REIMER et al. in review 2002). However, whether zooxanthellae digestion and coral bleaching occurs in *Zoanthus* under natural conditions in the field or not is unknown. As well, is there any variation in the upper critical temperature observed in the lab of 30 for the onset of bleaching and increase in DDZ with *Zoanthus* over a wide geographic range?
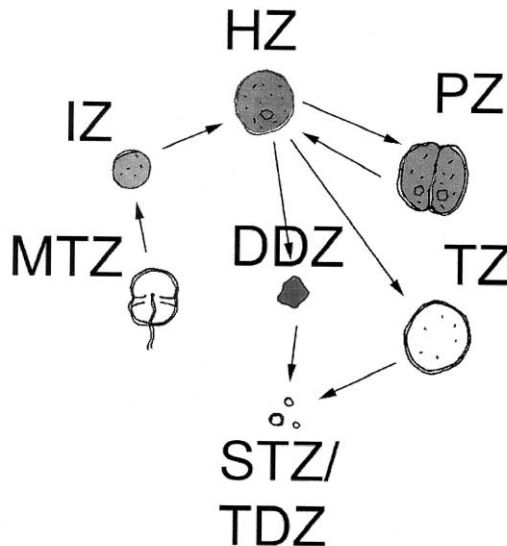
Fig.1. Body types of endosymbiotic zooxanthellae adapted from previous research (MCLAUGH
LIN et al., 1966; TITLYANOV et al., 1996; KUROKI & van WOESIK, 1999). Definition
of body types: 1) HZ - healthy zooxanthellae, characterized by their large (6-8 μ m in
diameter) circular shape, and greenish-brown color 2) PZ - proliferating zooxanthellae,
HZ undergoing mitotic division 3) DDZ - dark degraded zooxanthellae, smaller
in size and darker than HZ (usually approximately 3μm in diameter) and more
irregular in shape 4) TZ - transparent zooxanthellae, zooxanthellae that are charac-
terized by a near or complete loss of color (photosynthetic pigments) 5) STZ/TDZ -
small transparent zooxanthellae and transparent degraded zooxanthellae, very small
in shape (less than 3 μm in diameter) and colorless 6) MTZ - mobile transparent
zooxanthellae, characterized by their two flagella and bell-like shape, and 7) IZ -
immature zooxanthellae, zooxanthellae with photosynthetic pigments but not yet full
in size (approximately 4 μm in diameter).

Materials and Methods

Sampling

Samples of *Zoanthus pacificus* were collected each month from four field sites (Kokubu-Wakamiko (K), Sakurajima-Hakamagoshi (S), Yakushima-Kurio (Y), and Amami-Oshima-Kasari (A)). The four field sites are separated by a distance of almost approximately 400 kilometers

north-south. At each field site 5 locations at different depths and exposure were selected and one sample from each consistently collected. Collected samples were immediately placed in a cooler for transport.

Environmental data (pH, ocean temperature, salinity, conductivity, and dissolved oxygen content) were collected with a YSI Inc. Aquameter. Data was collected from each location at each site every month. The data was also supplemented by UV and temperature data from local weather stations.

Zooxanthellae Body Type Research

Immediately after sampling, endosymbiotic zooxanthellae were isolated from each *Zoanthus* sample by use of a 0.1-ml syringe and examined under a microscope at 400X using a hemo-cytometer. Zooxanthellae were classified into different body types (see Fig. 1 for a detailed explanation), and the results compared with environmental parameters (seawater temperature, salinity, DO, pH, etc.) over time. Counts were performed on each sample from each location at each site for five fields of view.

Transect Study

At both the Y and A sites, one inter-tidal location of dimensions 50 cm by 50 cm was selected. Photographs of each transect site were taken each month, and the percentage cover calculated using a computer-drawn grid. These data were compared over time against environmental data collected.

DNA classification of Zoanthus and zooxanthellae

Zoanthus and zooxanthellae both have been the subject of controversy with regards to classification, and no classification study of *Zoanthus* in southern Japan has yet been performed. Colonies of *Zoanthus* of oral disk color not reported in literature are numerous at all four sites. To confirm that our focus species is indeed *Zoanthus pacificus* and to shed light on the endosymbiotic zooxanthellae, classification to the DNA level is scheduled.

Samples of *Zoanthus* were collected from field sites in late August 2002. Collected samples were placed in marked bottles, and placed immediately into coolers away from direct sunlight exposure. Upon return to Kagoshima University labs, samples were wrapped in aluminum foil to prevent exposure to light, and placed in a deep freeze at -80 .

DNA analysis of both *Zoanthus* and zooxanthellae is currently being performed at the JAMSTEC headquarters in Yokusuka, Japan, starting from September 2002. While initial results are known, it is expected that conclusive results will not be ready until spring/summer 2003.

Results

The results of the zooxanthellae body type analysis when compared with seawater temperatures are shown in Figure 2. A close examination of the graphs shows that there are two major patterns, a northern pattern with winter 2001~2 decreases in healthy zooxanthellae (NZ) shown by K (a) and S (b), and a southern pattern displayed by Y (c) and A (d) with healthy zooxanthellae decreases in abnormally hot summer 2001. As well, the southern group shows either only a slight drop (Y) or no drop (A) in NZ ratios in winter. All sites showed little or no decrease in NZ ratios is summer 2002, when ocean temperatures did not rise much above average expected levels.

Figure 2(a) - Monthly Changes in NZ Ratio and Ocean Temperature, Wakamiko, Kokubu
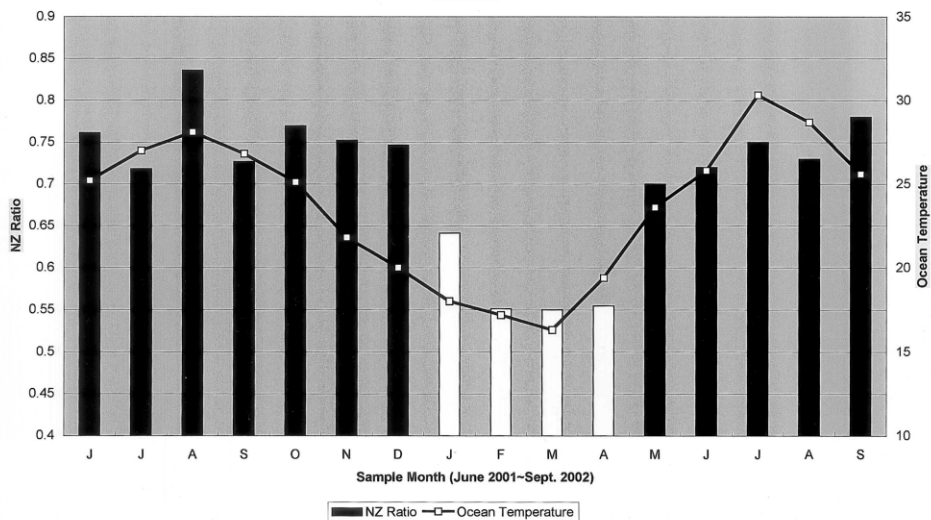
Figure 2(b) - Hakamagoshi, Sakurajima
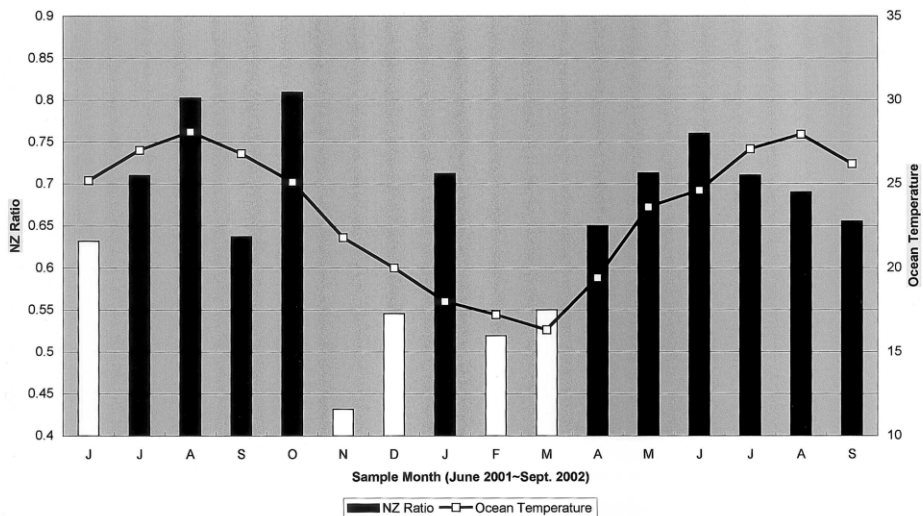
Fig.2. Monthly changes in NZ ratios at the four field sites. (a) Wakamiko, Kokubu, (b) Hakamagoshi, Sakurajima, (c) Kurio, Yakushima, and (d) Tomori Beach, Kasari, Amami-Oshima. Please note that black bars represent NZ values greater than 0.65 (thus 65% or higher NZ content), while white bars represent NZ values lower than 0.65, indicating stress.

Transect data of percentage cover of *Zoanthus* at Y and A are shown in figure 3. Both locations show a winter decrease in percentage cover that was not reflected in the zooxanthellae data. Summer data from 2002 is still being analyzed at the time of writing.

Figure 2(c) - Kurio, Yakushima
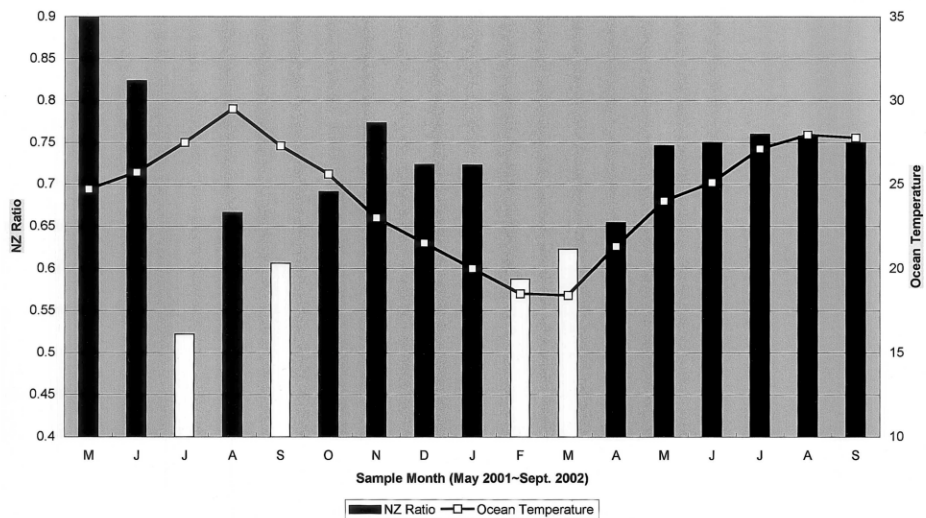
Figure 2(d) - Tomori, Kasari, Amami-Oshima
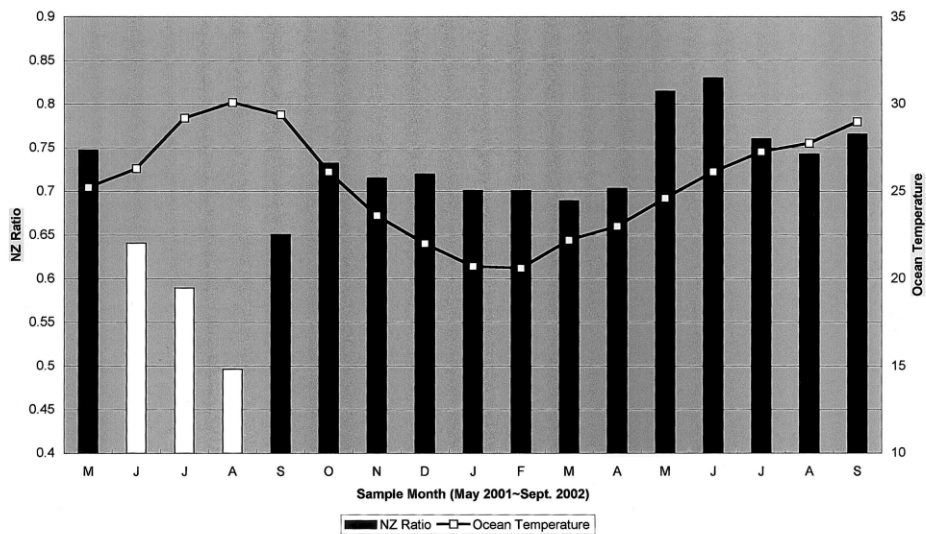
Discussion and Conclusions

The results in figure 2 and 3 indicate a low-end critical temperature for *Zoanthus pacificus* at approximately 15 , which is the winter minimum seawater temperature for the K and S sites. *Zoanthus* survives at this temperature, but the ratio of healthy NZ zooxanthellae decreases, and *Zoanthus* colonies experience winter contraction even at the warmer Y and A sites further south.

Figure 3 - *Zoanthus* Percentage Cover Results
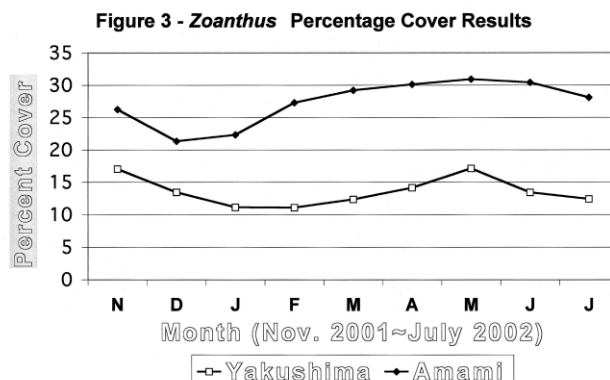
Fig.3. Monthly changes in percentage cover of Zoanthus at Yakushima and Amami-Oshima field sites.

Maximum seawater temperatures appear to be in the area of 30 for *Zoanthus* at all sites, as *Zoanthus* NZ ratios at Y and A sites decreased during the abnormally hot 2001 summer. K and S sites showed no summer decrease despite being further north and seawater temperatures being only slightly cooler.

One factor not shown in these calculations is the fact that length of exposure is also important. While seawater temperatures may fluctuate between 15 and 30 , *Zoanthus* at the Y and A sites are exposed during extreme tides, with many colonies not even in tidepools. A temperature of 13 has been recorded in a tidepool at Y during January 2002, and outside air temperatures reached as low as 2 . Conversely, at the A site in August 2002, a tidepool seawater temperature of 37.8 was recorded, and air temperature at all sites regularly can hit 35~36 in summer. It appears that *Zoanthus* and zooxanthellae can survive short (up to 6 hour) exposures to very extreme temperatures, but long-term differences of even 0.5 can greatly impact their survival. Summer 2002 data from Y and A further supports this, as the normal seawater temperatures observed (up to 27.8) did not cause any decrease in NZ ratios, as opposed to summer 2001 data.

An important question that remains to be answered is whether or not the summer decrease in NZ at Y and A is a recent phenomenon or not. Coral bleaching and associated problems are assumed to be a result of global warming yet our research shows that, at least at K and S sites, some stress in winter appears to be naturally occurring. With ocean temperatures expected to continue to rise in the future, the naturally occurring pattern of winter stress may switch to the summer stress pattern seen in Y and A samples in the summer of 2001. How these trends impact cnidarians and their zooxanthellae remains to be seen, but the overall prognosis given the sensitivity of *Zoanthus* and NZ ratios to even a small change (as seen in summer 2001) is not good.

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GENETIC HETEROGENEITY FOUND IN CROPS PLANTED IN SMALL ISLANDS

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Abstract

Some native crop cultivars planted in small islands differ genetically from those planted in other regions in Japan. Among such genes conferring genetic heterogeneity in small islands, *Hwc2* gene in rice was examined. Frequency of *Hwc2* gene has showed a latitudinal cline of Japonica types of the insular region. In this study, first, linkage analysis of *Hwc2* locus was performed. *Hwc2* gene cosegregated with *ph* gene on rice chromosome 4. This result was consistent with our previous study. Then, the significance of the chromosomal region of the *Hwc2* locus and the genetic heterogeneity of crops in small islands are discussed.

Key words: Genetic heterogeneity, *Hwc2*, Linkage analysis, Rice

Introduction

Some native crop cultivars planted in small islands differ genetically from those planted in other regions in Japan. For example, KAWASE and SAKAMOTO (1982) examined phenol color reaction (see Materials and Methods) of 376 strains of foxtail millet, *Setaria italica* (L.) P. Beauv., collected from different areas throughout Eurasia including Japan. Strains that showed the positive phenotype of phenol color reaction were found in Tsushima, the Nansei islands, Taiwan, Philippines, and India with high frequency. However, these cultivars were rarely found in other regions. Another example is red rice. It was expelled from most of Japan, but it is still planted for religious purposes in Homan Shrine in the Tanegashima island, and Takuzutama Shrine in the Tsushima island (WATABE, 1993). Such genetic heterogeneity is thought to be closely related to routes of the crops and geographical heterogeneity of these small islands.

Weak growth occurring in hybrids derived from crosses between two normal strains is called hybrid weakness. F_1 weakness of intraspecific hybridization has been reported in some cereal crops such as wheat *Triticum aestivum* L. (CALDWELL and COMPTON, 1943; TSUNEWAKI, 1970) and barley *Hordeum vulgare* L. (WIEBE, 1934; TAKAHASHI and HAYASHI, 1972). There are some hybrid weakness phenomena in rice, *Oryza sativa* L., (SATO, 1997). Among them, F_1 weakness found in crosses of a Peruvian rice cultivar Jamaica and Japanese lowland cultivars is controlled by a set of complementary genes, *Hwc1* and *Hwc2* (AMEMIYA and AKEMINE, 1963). *Hwc1* and *Hwc2* are carried by Jamaica and Japanese lowland cultivars, respectively. Genotypes of *Hwc1* and *Hwc2* loci are *Hwc1Hwc1hwc2hwc2* for Jamaica, and *hwc1hwc1Hwc2Hwc2* for Japanese cultivars.

Cultivated Asian rice is classified into two groups, Indica and Japonica. Japonica cultivars comprise two varietal groups, temperate and tropical types, the latter including cultivars classified in earlier studies as Javanica types (GLASZMANN, 1987; MACKILL,

1995). Distribution of *Hwc2* gene-carrier was surveyed in Asian native cultivars (Sato and Hayashi, 1983); the *Hwc2* gene was prevalent among temperate Japonica, but not among tropical Japonica or Indica. Most Japanese native cultivars carry the *Hwc2* gene while those from the Nansei islands and Taiwan carry *hwc2* with relatively high frequency. These Japanese cultivars carrying *hwc2* have many traits that are specific to tropical Japonica while most Japanese cultivars are temperate Japonica. Therefore, *hwc2* gene in rice is among the genes conferring genetic heterogeneity in small islands.

We identified the chromosomal location of the *Hwc2* locus by using 127 recombinant inbred (RI) lines segregating at the *Hwc2* locus (Ichitani et al., 2001). These RI lines are produced by continually selfing or sib-mating progeny of individual members of an F_2 population until homozygosity is achieved (Burr and Burr, 1991). Each RI line is fixed for a different combination of linked blocks of parental alleles; consequently, an RI family constitutes a permanent population in which segregation is fixed. Suppose that a hybrid weakness gene segregates in a set of RI lines. Crosses between RI lines and a line carrying the complementary hybrid weakness gene produce normal plants and weak ones showing hybrid weakness as in F_2 and backcross population. Plants showing weakness are difficult to analyze genetically. Therefore, F_2 or backcross is not an appropriate population for mapping *Hwc2*. The RI lines are appropriate for mapping *Hwc2* because RI lines in themselves, not the hybrids expressing weakness, can be analyzed for further genetic study. Information about presence or absence of hybrid weakness phenomena can easily be combined to accumulate a genetic data set of each RI line. This confers great advantages over usual segregating populations such as F_2 and backcross.

The present study examines 27 more RI lines; the more accurate location is determined. Then, significance of the chromosomal region of the *Hwc2* locus and genetic heterogeneity of crops planted in small islands are discussed.

Materials and Methods

A total of 191 RI lines have been developed by Fukuta et al. (1999) from the cross between a temperate Japonica cultivar Akihikari and an Indica cultivar Milyang 23. Preliminary experiments indicated that Akihikari carries the *Hwc2* gene while Milyang 23 carries neither *Hwc1* nor *Hwc2* (Fig. 1). Genotypes of 183 restriction fragment length polymorphism (RFLP) loci which almost cover the entire rice genome have been identified for F_5 individuals, from which each F_6 line was produced by the single seed descent method. Phenol reaction, one criterion to classify cultivars into Indica and Japonica (Sato, 1991), is controlled by a gene *Ph* on chromosome 4 (Nagao and Takahashi, 1963). Milyang 23, like most Indica cultivars, carries the dominant allele *Ph*, changing hull color into black after soaking in phenol solution. On the other hand, Akihikari, like most Japonica cultivars, carries the recessive allele *Ph*, leaving hull color in a phenol solution unchanged. The genotype of each RI line at the *Ph* locus has already been determined by Ichitani et al. (2001). The 27 RI lines which had not been examined by Ichitani et al. (2001) were crossed to the *Hwc1* carrier Jamaica as a pollen donor. Then, they were sown on petri dishes containing 5-mm-deep tap water. They were left in the dark at 28 for five days. Next, their roots were observed to find the genotype of RI lines at the *Hwc2* locus. At least six hybrid seedlings were observed in each cross combination. Estimation of the genotype of each RI line and linkage analysis for RFLP, *Ph* and *Hwc2* followed Ichitani et al. (2001).
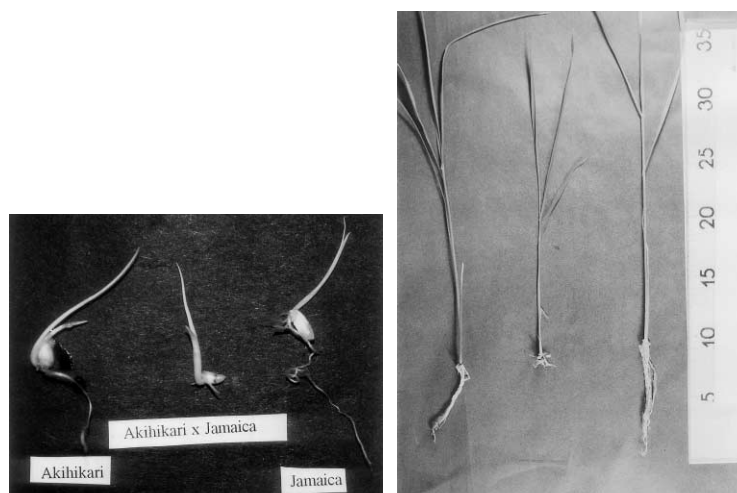
Fig.1. Growth of 'Akihikari' *(left)*, 'Jamaica' (*right*), and their hybrid (*center*) seedlings.
(a) Five days after sowing date. (b) One month after sowing date.

Results

The 27 RI lines were classified into three types: 10 lines fixed for *Hwc2* allele, 12
lines fixed for the *hwc2* allele, and 5 lines which had not reached fixation. The *Hwc2*
gene cosegregated with *ph* gene on rice chromosome 4. Addition of this result to ICHITANI
et al. (2001) led to the segregation ratio 58*Hwc2Hwc2* : 81*hwc2hwc2* : 15*Hwc2hwc2*; this
ratio deviated somewhat from 15: 15: 2, the expected ratio of gene constitution of F_6
lines bred through single seed descent method (χ^2= 6.87331, d. f. =2, 0.05>P>0.01).
The result of linkage analysis indicated that *Hwc2* and *Ph* were located together between
the two RFLP loci, X*Npb264* and X*Npb197*, on the long arm of the chromosome 4. The
genetic distance between *Hwc2* and *Ph* was modified by 0.11 cM to 0.49 cM from the
0.6 cM of ICHITANI et al. (2001). On the other hand, the genetic distance between *XNpb234*
and *Hwc2* was longer than that in ICHITANI et al. (2001) by 0.15cM; the genetic distance
between *Ph* and *XNpb197* was almost unchanged. The four loci, *Hwc2, Ph, XNpb264*,
and *XNpb197*, were rearranged in the order of *XNpb264 - Hwc2 - Ph - XNpb197*.

Discussion

From a phylogenetic point of view, it is interesting that the two loci *Hwc2* and *Ph*,
both of which have been associated with varietal differentiation, are closely linked to
each other. Many loci controlling morphological and physiological traits related to adaptability
are located near the *Hwc2* and *Ph* loci (ICHITANI et al., 2001). Moreover, recent advances
in molecular marker-assisted analyses have shown that the gall midge resistance gene *Gm2*
locus (CHAUDHARY et al., 1986; CAUSSE et al., 1994), quantitative trait loci (QTLs) for
cool tolerance at the booting stage (SAITO et al., 1995), drought resistance (CHAMPOUX
et al., 1995), and the number of large vascular bundles in the peduncle (SASAHARA et
al., 1999) were all located near the two loci, even though the linkage between the two

loci and QTLs was indirectly obtained from that between these QTLs and molecular markers linked to *Ph*. These facts suggest that these adaptability-gene combinations, rather than *Hwc2* or *Ph*, might cause or promote varietal differentiation. Genes on the *Hwc2* and *Ph* loci might be mutated and be dragged by surrounding gene combinations.

One indication that the *Ph - Hwc2* region may be involved in adaptation is seen in Japanese cultivars. AMEMIYA and AKEMINE (1963) reported that, unlike Japanese lowland cultivars, Japanese upland ones examined up to now carried *hwc2*. On the other hand, ISHIKAWA et al. (1992) reported that many Japanese upland cultivars carry *Ph* gene, though they carry the Japonica type allele at most isozyme loci and are classified as temperate Japonica. There is no information about correspondence between the two studies, but there is some possibility that Japanese upland cultivars conserve the *Ph - hwc2* linkage block. Rice is easily infected with blast fungus under the upland condition. To cope with blast, upland cultivars carry blast resistance genes. Linkage between *Ph* and a blast resistance gene(s) was detected in some Japanese upland cultivars (MARUYAMA et al., 1983; HIGASHI and SAITO, 1985; GOTO, 1988). The linkage block containing *Ph* and a blast resistance gene(s) is thought to have derived from exotic cultivars, probably Indica, and have survived introgression with temperate Japonica genetic background. Tight linkage between *Ph* and *hwc2* suggests that the *hwc2* gene may have been dragged by *Ph* and a blast resistance gene(s). A similar linkage block containing a blast resistance gene(s) and an upland-cultivar-specific isozyme gene on chromosome 11 was suggested by ISHIKAWA et al. (1997).

Hybrid weakness genes may be thought to be useless for practical breeding; however, a breeding scheme utilizing such genes is proposed for preventing the spread of transgene and genetic contamination of cultivars (SATO, 1997; SATO and INAMURA, 1989; YONEZAWA et al., 1990; MORISHIMA, 2001). There is a high probability that such potentially useful genes be identified in local cultivars planted in small islands. Moreover, genes can be tools with which origins and routes of crops can be traced. Local cultivars can be useful for ethnology and folklore, too. Skewed geographic distribution of the *Hwc2* gene in rice presented a good opportunity to reevaluate the idea that rice and rice cropping had proceeded to Japan northwards along the Nansei islands or the path on the sea (*kaijo no michi*) proposed by YAGAGITA (1961). WATABE (1993) reported that a traditional method of using cattle to plow paddy fields in the Nansei islands is also seen in insular regions of Southeast Asia. WATABE (1993) also reported that a few native cultivars in the Yaeyama islands looked like Bulu, a group of tropical Japonica native cultivars grown in Indonesia. These findings shed new light on rice diffusion and rice cropping. However, most local cultivars planted in small islands tend to be replaced by improved cultivars and are in danger of extinction. Exploitation and conservation of genetic resources is required for the future.

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Katsuyuki Ichitani and Yoshimichi Fukuta

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DISTINCTION OF MIXED WATER YAM'S STARAINS (*DIOSCOREA ALATA* L.) CULTIVATED IN YAKU ISLAND

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Abstract

This study clarified we could effectively distinguish mixed water yam strains by observing the differences of morphology of the leaves and tubers in Yaku Island. However, there are considerable variations in morphology, so we may be able to more confidently distinguish strains by also employing the electrophoresis method using acetone powder.

Key words: Mixed strains, Polyacrylamide gel electrophoresis, Water yam, Yaku Island

Introduction

What are generally called Yam in Japan are mostly Chinese yam (*Dioscorea opposita* Thunb., Naga-imo) or Japanese yam (*D. japonica* Thunb., Yamano-imo or Jinen-jyo), and both species are originally from temperate zones. However, among some 600 species of the *Dioscorea* genus plants (to which yam belong) said to exist worldwide, about 10 species are used for economic cultivation, most of which are originally from the tropical or subtropical zones. One of them, *D.alata,* or water yam in English, is called' Daijyo' in Japan. It is supposed to have originally come from Southeast Asia, but now can be found widely in Asia, Oceania, Africa and Central America. In Japan, it is cultivated in warm districts in the southwest and is mainly eaten uncooked or processed into sweets and buckwheat noodles.

Farmers in Yaku Island, Kagoshima prefecture, started economic cultivation of water yam in the town of Kamiyaku in about 1986. Some 18 hectares are now cultivated in both the town of Kamiyaku and Yaku, and the cultivated area is increasing. A storehouse and a processing factory were built in the town of Kamiyaku in 1992, and today, water yam is processed into grated yam, frozen, and shipped in 100g packs throughout the year.

The cultivated strain" Solo Yam", which Kagoshima University introduced from Indonesia, is used because of its high viscosity and good taste (ISHIHATA et al., 1977, 1984). However, as the years under cultivation and the cultivated area increased, other strains were mixed with" Solo Yam" in cultivation. Compared to" Solo Yam", these strains have extremely low viscosity and change colors easily during processing and have thus caused some problems in producing grated yam.

The authors previously reported that morphology, the RAPD method (SHIWACHI et al., 2000), and tuber protein are effective methods for distinguishing water yam strains (ONJO et al., 1995). In this study, we investigated whether it was possible to distinguish mixed strains in Yaku Island, using comparatively easy and cheap morphology and tuber protein.

Materials and Methods

Tubers were harvested, collected and stored at 15 in a storehouse in the town of Kamiyaku

in December 2000. Nine tubers that differed in shape by the naked eye were chosen in February 2001 and used as samples in this experiment. First, the weight, width (maximum and minimum), and length of each tuber were measured. We then hollowed out the center of the tubers, measured water percentage and produced acetone powder. The water percentage of the tubers was determined by drying about 10g of fresh tubers at 120 for 72 hours and then measuring the weight of the dried tubers. Next, the tubers were cut into 50 to 70g samples, sterilized them by a normal method, and then planted them in 10-liter cloth pots on May 10, 2001. We kept only one of the sprouted stems and cut the rest off. The selected stem was then trained onto a 1.2m prop. Following the standard given by Breeding Department of National Research Institute of Vegetables, Ministry of Agriculture, Forestry and Fishery (TAKAYANAGI et al., 1984), we investigated the morphological characteristics of the top on September 1, when it was a good growing season.

Acetone powder was produced as follows. We put about 15g of fresh tuber into an appropriately cooled nyubachi and quickly smashed it while pouring on acetone that had been cooled down to -20 . It was then filtered and dried to obtain acetone powder and the powder was stored at - 20 . The amount of powder obtained is given by the weight % of powder to the weight of the smashed fresh tuber. With this acetone powder, we tried to distinguish the mixed strains using polyacrylamide gel electrophoresis. In both investigations, we used "Solo Yam" preserved and subcultivated by Kagoshima University as a control and tried to distinguish the mixed strains by comparing them to the nine tuber samples from Yaku Island.

Results and Discussion

1. Morphological and physiological characteristics of the top and the tuber

Table 1 shows the result of the morphological characterization of the top. No clear differences were observed among individuals in growth of stems and all parts above the ground. However, two samples, Y7 and Y8, did not exhibit the coloring of anthocyanin on the wing part of the stem, one of the characteristics of water yam. This anthocyanin coloring can be used as an indicator to distinguish the water yam's strain (SHIWACHI et al., 2000). It was therefore presumed that Y7 and Y8 were not " Solo Yam". We next looked at the morphology of the leaves. Although it was observed considerable differences among individuals for each investigation item, but there was no constant tendency. However, observing with the naked eye, it is noted that the leaf of "Solo Yam" was heart-shaped whereas those of Y2, Y7 and Y8 were wedge types. Measurements confirmed that only Y2, Y7, and Y8 leaves had widths of less than 7cm and shoulder widths of more than 4cm.

Tables 2 and 3 show morphological and physiological characteristics of the tubers. The flesh color of the tuber, color changes in cutting and viscosity vary to some extent according to the cultivation or storage conditions. The flesh color of the tuber and viscosity was thought to be within this variation. However, the color changes were remarkable in Y2, Y7 and Y8 and were considered to be bigger than the variation due to the conditions above. It was therefore possible that this was due to the characteristics of each individual. Next the tuber shapes were compared. The length/width ratios were large in Y2, Y6, Y7 and Y8, which were long and thin compared to "Solo Yam". Water percentage of the tubers and the collection rates of the acetone powder differed in each individual.

2. Distinction by polyacrylamide gel electrophoresis

Fig. 1 shows the result of polyacrylamide gel electrophoresis. Y1, Y2, Y4, Y5, Y6 and Y9 appeared to be the same type as "Solo Yam" when detected band patterns were compared. However, a band that was not seen in "Solo Yam" was detected in Y2, Y7 and Y8 (arrows in Fig. 1). We hence

assumed that proteins in the tubers were different. From electrophoresis results, Y2, Y7 and Y8 would be different strains.

Judging generally from the results above of morphological, physiological and electrophoresis methods, we considered samples Y2, Y7 and Y8 to be of different strains.

Table 1-1. Morphological characters in 9 samples of cultivated yams collected from Yaku Island (Continued over).

| Sample No. | Plant vigor | Type of branches | Stem | | | |
			Type of twining	Shape of cross section	Diameter (mm)	Wing Color
Y1	3	5	2	2	2.6	2
Y2	3	3	2	2	2.5	2
Y3	5	3	2	2	2.9	2
Y4	5	5	2	2	3.3	2
Y5	5	5	2	2	3.1	2
Y6	5	5	2	2	2.7	2
Y7	5	5	2	2	2.9	1
Y8	5	5	2	2	2.4	1
Y9	5	5	2	2	2.5	2
Solo Yam	5	5	2	2	2.7	2

The items and methods are based on discrimination for Yams of National Research Institute of Vegetables, Ministry of Agriculture, Forestry and Fisheries.

Table 1-2. Morphological characters in 9 samples of cultivated yams collected from Yaku Island (Continued from Table1-1).

| Sample No. | Leaf | | | | | | |
	Length (cm)	Width (cm)	Depth of shoulder (cm)	Width of shoolder (cm)	Length of petiole (cm)	Index of leaf shape	Ratio of length of petiole and leaf length
Y1	14.5	7.9	3.5	2.5	5.4	1.83	0.37
Y2	12.5	6.0	2.6	4.8	6.2	2.09	0.50
Y3	15.1	7.9	3.7	2.7	5.7	1.91	0.38
Y4	15.0	8.5	3.7	3.2	5.7	1.77	0.38
Y5	16.7	8.9	4.0	3.9	5.7	1.88	0.34
Y6	15.7	9.0	3.6	3.8	6.5	1.74	0.41
Y7	15.3	6.8	3.2	4.7	5.5	2.23	0.36
Y8	12.5	6.7	3.2	5.1	5.0	1.87	0.40
Y9	15.0	7.5	3.5	1.9	5.2	1.99	0.35
Solo Yam	14.2	7.1	3.3	3.2	4.5	2.34	0.32

Table 2. Physiological characters of tested tubers.

Sample No.	Fresh color	Changes of color	Viscosity
Y 1	Cream	Non	Strong
Y 2	White	Red brown	Strong
Y 3	White	Non	Strong
Y 4	Cream	Brown	Middle
Y 5	White	Non	Strong
Y 6	White	Non	Middle
Y 7	White	Red brown	Middle
Y 8	White	Red brown	Middle
Y 9	Cream	Non	Middle
Solo yam	White	Non	Strong

Table 3. Morphological characters, water contents and yield of acetone powder of tested tubers.

Sample No.	Tuber			Water content (%)	Yield of acetone powder(%)
	Length (cm)	Width (Max.) (cm)	Length /Width		
Y 1	10.0	8.9	1.1	82.6	18.4
Y 2	13.3	4.1	3.3	77.0	25.5
Y 3	14.4	7.9	1.8	83.3	19.6
Y 4	8.9	6.8	1.3	81.5	18.6
Y 5	13.3	8.4	1.6	82.9	19.1
Y 6	8.8	7.7	2.2	82.0	17.8
Y 7	19.0	8.5	2.2	76.8	22.4
Y 8	16.3	6.9	2.4	80.6	21.7
Y 9	12.7	7.2	1.8	85.3	16.2
Solo Yam	11.3	7.1	1.6	77.7	25.2

Y1 Y2 Y3 Y4 Y5 Y6 Y7 Y8 Y9 Solo Yam
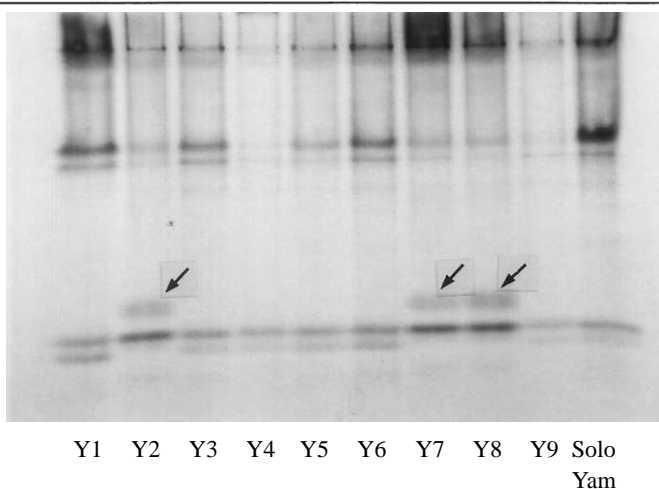
Fig.1. Band pattern of tuber protein using polyacrylamide gel electrophoresis.

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POSSIBILITY OF EARLY-SEASON CULTURE OF WATER YAM (*DIOSCOREA ALATA* L.) IN YAKU ISLAND

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Abstract

Early-season culture of water yam (*Dioscorea alata* L.) was required in Yaku Island, because of the long growing period, the concentrating work at the harvesting time, the lack of storehouse and so on. Thus we tried to search the early-maturing strains and use a plant growth regulator that promote the tuber enlargement. Then we found out the extremely early maturing strains introduced from high altitude area in the Kingdom of Nepal. On the other hand, foliar applications of gibberellins promoted the tuber enlargement. These results suggest the possibility of early-season culture of water yam. Further research would be required to use the new strains and the plant growth regulator.

Key words: Early maturing-strain, Early-season culture, Gibberellins, Water yam, Yaku Island

Introduction

Water yam (*Dioscorea alata* L.) is cultivated commercially in Yaku Island, and strains of " Solo Yam" that Kagoshima University introduced from Indonesia (ISHIHATA et al., 1977, 1984) are cultivated in the town of Kamiyaku. In normal cultivation, " Solo Yam" is planted from the beginning to the end of April and is harvested from the beginning to the middle of December when the tuber has matured, occupying the field for a long time since the cultivation takes so long. This has become a problem because it makes crop rotation with other crops difficult. In addition, as the work is concentrated at the time of harvest, labor supply and the lack of storage space are also causing problems. Breeding of an early-maturing strain with a short growth period may solve these problems. However, water yam has very rarely flowers, and hybridization has rarely been attempted anywhere in the world (ONWUEME, 1978). Thus, we searched for an early- maturing strain with early harvesting time and examined the possibility of chemical control with a plant growth regulator that might promote the tuber enlargement.

Materials and Methods

Experiment 1. Searching for an early-maturing strain

Searching for an early-maturing strain: We first tried to determine the earliness of the water yam strains that had been collected and preserved by at Kagoshima University since the latter half of the 1970s (ISHIHATA et al., 1977). We chose some representative strains, planted their seed tubers in the field at the beginning of May, and investigated the tuber enlargement by keeping records over time.

Late-maturing strains of water yam tend to be found in tropical lowlands where cultivation temperatures are less limited. We hence assumed that early-maturing strains could be found in the tropical or subtropical zone highlands where cultivation temperature is rather limited. Thus, we introduced

water yam strains cultivated in the highlands of the Kingdom of Nepal (600 to 1,800m above sea level) to Kagoshima and planted their seed tubers in the field at the beginning of May, as for the tubers of Kagoshima University, to investigate the tuber enlargement with elapsed time.

Experiment 2. Promoting tuber enlargement with a plant growth regulator

Use of a plant growth regulator: Preliminary examination showed that applying a general plant hormone, gibberellins (GAs), to foliage promoted water yam tuber enlargement. We then used two strains in the experiment, "Arata" a native of Kagoshima, and "Solo Yam" introduced from Indonesia. At the beginning of July, we applied GAs in concentrations of 0, 10, 100 and 1,000ppm to foliage to investigate the best GAs concentration for promoting tuber enlargement.

The tubers were planted in 10-liter cloth pots, and the stems were trained onto a 1.2m prop.

Results and Discussion

Experiment 1. Searching for an early-maturing strain

Fig. 1 shows how tuber enlargement of the preserved strains of Kagoshima University changed with time. The Oosato No.1 dried tuber weighed 3.1g on the 70th day after planting, while tubers of the other strains weighed less than 2g. This demonstrated that Oosato No.1 started tuber enlargement earlier than the other strains. Furthermore, Oosato No. 1 started rapid tuber enlargement around the 100th day after planting, whereas No. 36, Arata, and No. 59 started on the 100th to 130th day and Solo Yam on the 130th to 160th day. This proved that the strain of Oosato No. 1 started tuber enlargement about two months earlier than Solo Yam.

Based on the above result, we decided to use Oosato No.1, which started the tuber enlargement the earliest among the preserved strains, as a standard and compared it with the enlargement pattern of the strains introduced from Nepal (Fig. 2). Among the five strains that we had brought in from Nepal, N-1, N-3, N-5 and N-6 started tuber enlargement on the 70th to 100th day, which was about 15 to 30 days earlier than Oosato No.1.

N-1 in particular continued excellent tuber enlargement from the 100th day to the 160th day after planting, and the weight of the dried tuber on the 160th day at harvest time was 1.5 times that of Oosato No.1. This result clarified that four out of the five strains that we had brought in from Nepal started tuber enlargement even earlier than Oosato No. 1 that was native to Kagoshima.

N-1 and N-6 had been collected from villages that were more than 1,700m above sea level. The average temperature of August (January) at 1,740m above sea level is 20.4 (9.0
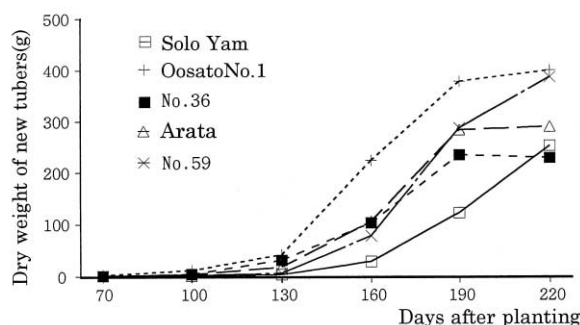
Fig.1. Changing in dry weight of new tubers in water yam collected from South-East Asia and Kagoshima, Japan.

). Hence the latter half of the growing period of yam cultivated in these areas could be under quite low temperatures. Therefore, we can consider that earlier maturing strains would be found in regions high above sea level where the temperature falls quicker.
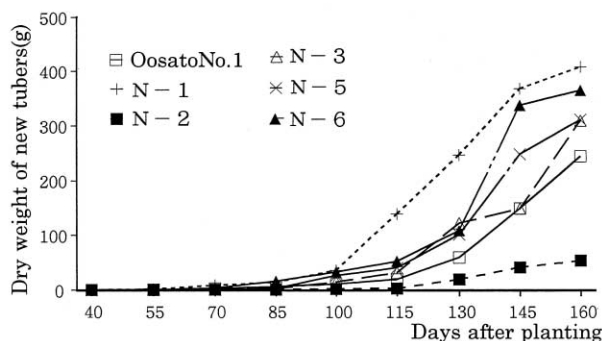
Fig.2. Changing in dry weight of new tubers in water yam introduced from Nepal.

Experiment 2. Promoting tuber enlargement with plant growth regulator

Table 1 shows the effect of GAs on tuber enlargement. We applied GAs at the beginning of July when tuber enlargement was stagnant. The fresh weight of the new tubers increased in both Arata and Solo Yam strains, which showed that GAs promoted tuber enlargement. The effect was particularly remarkable in 100ppm and 1,000ppm application divisions, the fresh weight of new tubers in the 1,000ppm division was 15 times that in the 0ppm division for Solo Yam and about twice for Arata. Whether this large diversion of promotion effect between the strains is due to their difference of sensibility to GAs or due to the variation of the growth stage at the time of application will be discussed in the future.

GAs is generally known as a plant hormone controlling the growth of a plant. It is widely used in agriculture, with seedless vines for example. It is safe and can be obtained cheaply anywhere. The fact that GAs promotes tuber enlargement will open up a way to use chemical control for early cultivation of water yams.

Table 1. Promotion effects of tuber enlargement by gibberellins treatment in water yam (*Dioscorea alata* L.).

Gibberellins concentrations (ppm)	Fresh weight of new tubers （g）	
	Solo Yam	Arata
0	1.2a*	6.0a
1	1.2a	4.8a
10	2.3a	8.8ab
100	4.0a	11.7b
1,000	18.7b	12.5b

*:Different figures show the significant differences at 5% level.

Michio Onjo

It will then be necessary to examine the amount of harvest, viscosity and tastes of the strains introduced from Nepal. Furthermore, the possibility of combining existing strains and Nepal strains in actual cultivation and of chemical control of those strains using GAs needs to be discussed in the future.

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POPULATION STRUCTURE AND GROWTH DYNAMICS OF *CASTANOPSIS SIEBOLDII* IN SECONDARY-AND OLD GROWTH-SUBTROPICAL FORESTS IN SOUTHERN JAPAN

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Abstract

Population dynamics of *C. sieboldii*, based on comparing secondary and old growth stands in the subtropical forest, was investigated. The old growth forests showed higher recruitment rate of *C. sieboldii* than that of the secondary forests. Gain of stand biomass was smaller in the old growth forests, but their biomass lost to mortality was larger than that of the secondary forests. Above ground net primary productions ranged from 1.19 kg/ha yr to 1.57 kg/ha yr. Relatively high species diversity in the old growth stands may be maintained by competitive effects of the *other species*.

Key words: Demography, Competition, Net primary production, Regeneration, Species diversity

Introduction

Tree communities of Yanbaru are subtropical evergreen broad-leaved forests dominated by *Castanopsis sieboldii* (SUNAKAWA & YAMAMORI, 1964, OHYAMA & YAMAMORI, 1971, SUZUKI, 1979, HATSUSHIMA & NAKAJIMA, 1979, ITOW, 1985, Oono et al., 1997). Natural forests of Yanbaru, which is located in Okinawa Island of southern Japan, support many endemic and endangered birds and mammals (see review by ITO, 1997). The area of old growth forests are rapidly diminishing due to intensive logging, consequently, most of the current forested areas are secondary stands regenerated after clear cutting (U.S. Civil Administration of the Ryukyu Islands 1953). Regeneration dynamics of the secondary forests as well as maintenance mechanisms of the intact forests have become an important issue in the management of seral stands (AIDE et al., 1995, GARCIA-MONTIEL & SCATENA, 1994, AIBA et al., 2001). Nevertheless research on the dynamics of the subtropical forests with structural attributes similar to both humid tropical montane rain forests and warm-temperate evergreen broad-leaved forests is scant in comparison to the tropical forests of Southeast Asia (but see ZHUANG & CORLETT, 1997).

Comparative analysis of permanent plots with different age or history might provide insight into structural changes (UUTTERA et al., 2000). In order to reconstruct stand development over time, it is necessary to clarify differences of structural attributes in several stands (FINEGAN, 1992, 1996, GRAU et al., 1997, DENSLOW & GUZMAN, 2000), because demographic traits such as growth rate and mortality change with stand development (KOHYAMA, 1987, BORMANN & LIKERS, 1994, BAZZAZ, 1996). Differences in the spatial- and temporal-patterns of these traits are likely to drive stand dynamics (UMEKI & KIKUZAWA, 1999), may leading to a variation in species diversity in old growth stands.

This paper investigates the differences of the structures and dynamics between secondary and old growth forests in Yanbaru of Okinawa Island, southern Japan. The first object is to present an overview of the regeneration process of the most dominant species (*C. sieboldii*) from secondary

to old growth forests. The second is to examine the effects of competition among individual trees on the community dynamics. This is because intra-and inter-specific competition are important factors governing self-organization of forests (e.g., KOHYAMA, 1993, HARA et al., 1995, NAKASHIZUKA & KOHYAMA, 1995, KUBOTA & HARA, 1995). Most previous studies have presumed autogenic effects to be constant, irrespective of stand development. It is not clear whether the mode of competition among member species can be assumed to be constant throughout all the developmental stages. The first part examines the stability of competitive effects in secondary and old growth stands, and explores the community dynamics of this subtropical forest that bring the coexistence among *Castanopsis sieboldii* and a variety of subordinate species.

Study Site I

The study was conducted in Yanbaru (26° 44'N, 128° 14'E), the northern mountain part of Okinawa Island, southern Japan. This region is located between the warm-temperate and tropical zones (MIYAWAKI, 1980). Mean monthly temperature is 19 - 22 ; mean daily temperatures in the warmest month (July) and the coldest month (January) are 27.3 and 14.2 , respectively. Precipitation ranges from 1900 to 4000 mm year^{-1}. Typhoons with strong winds and rain frequently strike the island between July and October. Winds are generally from the south or south-west in summer and from the north in winter. Stand canopies have been apparently shaped by the winds into a homogeneous, continuous surface. As a result, unlike the tropics, there is no emergent tree. The bedrock is composed mainly of tertiary sandstone, palaeozoic clay-slate, and a red-yellow forest soil that lacks humus layer develops (Forest Soil Division, GFES, 1976, KOJIMA, 1980). The study site is dominated by evergreen broad-leaved trees such as *C. sieboldii, Distylium racemosum,* and *Schima wallichii*. Nomenclature follows HATSUSHIMA & AMANO (1994).

Methods

Stand selection and site condition

In order to carry out intensive investigation of structural changes and growth dynamics in forests of different ages, four stands were selected from forested area based on the description by ITO (1997). In Dec. 1997 and Mar. 1998, one monitoring plot was established for each stand which are located within it on a slope at approximately 100 - 400 m elevation. Their areas range from 0.04 to 0.09 ha depending upon the topographic conditions and the stem density. Relatively small plot sizes were used in this study for minimizing topographical heterogeneity within a monitoring plot such as the presence of small ridge and valley (e.g., SHINJO et al., 1988, 1991, 1992, MIYAGI & SHINJO, 1989, 1990). Stands 1 and 2 are secondary forests of approximately 15 and 30 years, respectively. Both were subjected to clear cutting. In Stands 1, saplings of *Styrax japonicus* were planted just after logging, and no additional treatment such as mowing and thinning was conducted. The time of abandonment age of each stand was estimated from aerial photographs taken in 1977 and 1995, from the logging record of Kunigami Village, and from interviews with local inhabitants. The older Stand 3 is located in the Yona Experimental Forest of the Ryukyu University and the oldest Stand 4 is in Mt. Yonaha Cultural Properties Preservation Area (ITO, 1995). The former was once logged and naturally regenerated, and is currently more than 50-year-old, while the latter has been conserved for longer period.

In this region, most of the human operations were not recorded in detail because of the confusion during the World War II and the following occupation of the United States Military Forces. This makes the present vegetation exceedingly difficult to interpret. Therefore, in order to validate the comparative analysis among the four stands at different ages, we first examined their site conditions,

soil property and decomposition process of leaf litter fall.

Forcing a core sampler systematically in plots, we collected topsoils (0 - 15 cm) from four to nine points beneath the litter layer. The visible fine to coarse roots, stones, and plant debris in the collected samples were removed, and soil pH (in distilled water) of the sampled topsoils was measured for each plot. Remnant soil samples were oven-dried at 105 for 48 h, and then total nitrogen contents were determined by the micro Kjeldahl procedure (BUCHI Kjeldahl Line B-324, Switzerland).

Randomization technique with the bootstrap resampling was used to test the significant differences of pH and the total nitrogen in topsoils among the stands. Test statistic was obtained by permuting the observed data of pH or total N of the stands and then calculating the sum of the deviations over the stands. We recalculated the statistic 1000 times, generating a distribution of the sum of the deviations over the stands. By comparing these two sums of the deviations over the stands to this generated distribution, a significance level can be determined (ADAMS et al., 1997).

Decomposition rate of leaf litter of *C. sieboldii* was examined as an index of mineralization rate by the litter bag technique. *C. sieboldii's* leaf litters (5 g of air-dried) were enclosed in each bag (15 cm x 15 cm with 1 mm polyethylene mesh), and the bags were placed on the forest floor. The litter bags were collected every 3 months from April 2001 to May 2002. Leaf subsamples were oven-dried at 70 , and the mean dry mass remaining at each interval was expressed as a percent of the initial weight and adjusted to the exponential model: $W_t/W_o = e^{-kt}$ (Olson 1963), where k (the decomposition rate) was estimated by the regression analysis. To test for significant differences among slopes, k, of the four stands, the ANCOVA was used.

Species richness and diversity

To compare species richness among the plots, the relationship between area and number of species was investigated. Resampling within a plot was repeated 500 times for each subsample size. Minimum sized subsample was set as a 2 x 2 m unit. The number of species was averaged to determine as a function of size of the subsample. To compare species richness among the stands, two jackknife estimators were used (PALMER, 1990, 1991). Species diversity was described by the Simpson diversity index, 1-D (LANDE, 1996), Shannon-Wiener information index, H', and Pielou's equitability index, J'. D is the best index for comparative studies, because values of D are not affected by the sample size (tree density) and the confidence intervals become reasonably small with 50 - 100 individual samples (see review by LANDE, 1996). In order to avoid the sampling bias such as plot size, the D value was calculated at the 10 x 10 m subplot level, and then be averaged as a representative value at the plot level. Significance differences of the D value between the plots were examined by Mann-Whitney U test. Statistical analysis in terms of species richness and diversity was performed with the *PC-ORD_{version 4}* software (MCCUNE & MEFFORD, 1999).

Stand structure and dynamics

Each plot was first covered with a 2 x 2 m grid system for field survey. Thus 1325 grid cells of 2 x 2 m were established in total. Three life stages were defined for tree species: (i) canopy trees [DBH (stem diameter at breast height 1.3 m)   10 cm]; (ii) understory trees (2 m in height and < 10 cm in DBH); and (iii) saplings (10 cm   height < 200 cm). All living canopy and understory trees, including all multiple stems, were tagged and identified by species. The saplings were also tagged in systematically chosen grid cells. The height, DBH, and the location of all the stems were measured. When a stem had an irregular shape at 1.3 m height, the measurement was taken at the nearest higher point where the stem was cylindrical. Either steel measuring tapes

or calipers was used to measure DBH of the tree to the nearest 1 mm or 0.1 mm, respectively. DBHs of these tagged trees were remeasured in March 2000, and the new recruits of saplings (< 2 m height) which exceeded the minimal census size (height   2 m) were measured for DBH and identified by species. Significant difference of the sapling density, the understory density, and the canopy tree density among the stands was examined by Kruskal-Wallis test using the data at the 2 x 2 m grid level.

The relationship between DBH (x) and absolute growth rate (y) was given as logistic growth function:

$$y = a/(1 + b*exp(-c*x)),$$

which is specific to the tree species in early growing stage (Ford, 1975, Kikuzawa, 1988, Hara et al., 1991). Fitting of this model was carried out by non-linear regression analysis (Quasi-Newton method) using absolute growth rate as the dependent variable and DBH as the explanatory variable (Non-linear regression module; program from STATISTICA™ for Windows (Stat Soft Inc.)). The parameters of the model are shown in Fig.3. To test for significant differences in three parameters of the regression functions between-species or -stand, the procedure described by Dobson (1990, pp.116-119) was used. For instance, if we test a difference of parameter ' a ' in logistic growth functions between Species 1 and Species 2, we estimated parameters, a_{all}, b_{all}, and c_{all}, for the pooled species by non-linear regression analysis, calculating the sum of the independent contributions of the residual of observed values from the expected ones weighted by the residual of observed values (D_1). Next we estimated parameter, a_{sp1}, for Species 1 separately using b_{all} and c_{all} fixed as above estimated as the pooled species, calculating the sum of the independent contributions of the residual of observed values from expected ones weighted by the residual of observed values (D_2). In the probability density of the $^2_{N1+N2-P}$-distribution, the null hypothesis $a_{all} = a_{sp1}$ was tested with $D_1 - D_2$. In this way, differences of three parameters among the species and among the stands were compared.

The mortality and recruitment rates were calculated by using a logarithmic model (Condit et al., 1995, Sheil & May, 1996). The mortality rate (% year[-1]) is the log-transformed value of the number of initial live trees in 1997 (or 1998) divided by the number of surviving trees during 1997-2000 and by 2 (or 3) (years). The recruitment rate (% year[-1]) is the log-transformed value of the number of live trees at the end of the study divided by the number of surviving trees during 1997-2000 and by 2 or 3 (years). Significant differences of the observed mortality and the recruitment among the stands were tested based on the sum of the deviations of the observed values from that of the resampled values generated by the bootstrap method (1000 iterations). The significant level was determined from the probability of randomized statistic equal to or larger than that of the observed statistic.

Net primary production

In order to estimate net production of the stands and seed dispersal of *C. sieboldii*, litter fall was collected in five o nine traps with a horizontal area of 0.95 m^2 from 1997 to 2002 in each plot. Litter fall was usually collected every three months from October 1997 to February 2002. The contents of each trap were dried at about 70 oC. After drying, the collections were sorted into five fractions: leaves, small wood, seeds, frass and unclassified materials. All the sorted collections were dried at 70   and weighted separately for each trap.

For *C. sieboldii*, the number of dispersed seeds was counted in the four plots from October 1997 to February 2002. Seed production in the plots was calculated by extrapolating the average density of seeds per trap area to the total plot area. Then analysis of variance (ANOVA/MANOVA module; program from STATISTICA™ for Windows (Stat Soft Inc.)) was used to test differences of seed production between- year and between-stand.

Biomass was estimated by the following equations:

$$\ln w_S = 0.92 * \ln D^2 H - 3.21 \ (P < 0.0001, \ r^2 = 0.97),$$

$$\ln w_B = 1.02 * \ln D^2 H - 5.37 \ (P < 0.0001, \ r^2 = 0.82),$$

$$\ln w_L = 0.82 * \ln D^2 H - 5.62 \ (P < 0.001, \ r^2 = 0.71),$$

$$\ln L_A = 0.856 * \ln D^2 - 1.583 \ (P < 0.001, \ r^2 = 0.83),$$

and

$$w = w_S + w_B + w_L,$$

where D and H are DBH (cm) and height (m), respectively, and $w_S, w_B,$ and w_L, are the dry weights (kg) of stem, branches, and leaves per tree, respectively, and LA is leaf area (m^2) per tree, and w is the total above-ground dry weight of the tree. These regression equations were obtained from the studies done on the Yona Experimental Forest of the Ryukyu University (KAWANABE, 1977). Above ground net primary production of stand biomass (ANPP) was calculated with the method proposed by KIRA and SHIDEI (1967) and CLARKl et al. (2001a):

$$\text{ANPP} = \quad Y + \quad L + \quad G$$

where $\quad Y$ is the difference in standing live biomass between one measurement period and the next (including ingrowth). Above ground biomass of the minimum sized tree (2 m in height, $w = 0.01$ kg per tree) that recruited during the interval is removed from $\quad Y$. $\quad L$ is the amount of litter/branch fall during the interval. $\quad G$ is the amount of losses to herbivory that is calculated from the model (FURUNO & SHIRAI, 1970, YODA, 1971):

$$G = 1.2 * E$$

where E is the amount of frass.

Measurement of competitive effect

In order to assess competitive effects, we analyzed the crowding index of individual trees, which is the cumulative foliage area of neighbor trees higher than the focal tree (KUBOTA & HARA, 1996, HARA et al., 1995). It expresses the asymmetric competitive effect on the focal tree, in other words, the shading effect. The crowding index of individual trees was calculated at three neighborhood radii, 2 m, 3 m, and 5 m to find the best value for analyzing between-tree interaction (see below). Periodic (wrapped-around) boundary conditions, i.e. opposite edges of the plot were joined to form a torus were employed (YOKOZAWA et al., 1998), because trees close to the plot edges had neighbors outside the plot that were not measured.

Trees were grouped into *C. sieboldii* and the other species to better describe the community dynamics, because *C. sieboldii* was very dominant and practically determined the structure of the stand (SHINZATO et al., 1986). We calculated crowding indices of *C. sieboldii* and *other species* (pooled) trees, respectively. To examine inter- and intra-specific competitive effects between *C. sieboldii* and the *other species*, multiple linear regression analysis was conducted using DBH increment of each tree as the dependent variable and the log-transformed DBH and the crowding index as the explanatory variables for pooled data of each species (Multiple-linear regression module; program from STATISTICA^{TM} for Windows (Stat Soft Inc.)). The DBH increment was Freedman-Turkey-transformed to have a constant variance of residuals. Then inter- and intra-specific competitive effects of *C. sieboldii* and *other species* were investigated. Significance of the estimated values was tested by using a forward stepwise method at $P < 0.05$, and comparison of the estimated coefficients with possible values they take if individuals were randomly distributed in each stand. In this case, the null hypothesis is that bivariate spatial interactions between two groups of *C. sieboldii* and *other species* is independent. Based on the highest and the lowest values of competitive effects obtained from the randomized points, ninety-five percent confidence envelopes were drawn (DUNCAN,

Yasuhiro Kubota

1991, Nanami et al., 1999).

Results

Stand structure

Topsoils (15 cm) at all the sites were weakly acidic ranging from 4.07 to 5.21. Total N was quite low, although total N of Stand 4 was slightly higher than that of the other stands. No significant difference in soil acidity (pH) and total N among the four stands were shown (Table 1, $P > 0.1$ by randomization test based on the resampling data using the bootstrap method with 1000 iterations), although stand biomass and tree density do vary with stand history. Decomposition rate also did not differ significantly between the four stands (ANCOVA, $P > 0.9$). Significant correlations among log-transformed tree density, above-ground biomass, and mean above ground tree weight (Table 2, $P < 0.05$) can be ascribed to a difference of the stand ages among the plots, rather than the differences of the site conditions.

C. sieboldii commonly dominated throughout secondary and old growth forests (Table 2). Species richness with jackknife estimators was higher in younger secondary forests than in old growth forests (Fig.1, Table 3). Stand 1 had the greatest number of species in spite of its smaller plot area. High species richness in secondary forests was due to the occurrence of light demanding pioneer tree species such as *Euscaphis japonica, Mallotus japonicus, Ligustrum liukiuense* and *Pittosporum tobira*. But species diversity was slightly higher in old growth forests (Mann-Whitney *U* test, $P < 0.05$, Table 3), which is consistent with the findings that species diversity increases with forest age in old forests (age 50 yr) of Yanbaru reported by ITO (1997).

Table 1. Description and site data for secondary forests and old growth forest.

	Plot			
	Stand-1	Stand-2	Stand-3	Stand-4
Age (yr)	15	30	50-100	100<
History	Clear cut /Secondary	Clear cut /Secondary	Old Growth	Old growth
Altitude (m)	340	200	300	410
Bedrock[1]	Tertiary sandstone, palaeozoic clay-slate, yellow soil	Tertiary sandstone, palaeozoic clay-slate, yellow soil	Tertiary sandstone, palaeozoic clay-slate, yellow soil	Tertiary sandstone, palaeozoic clay-slate, yellow soil
pH (H_2O)[2]	4.91	5.21	4.07	4.65
Total N (%)[3]	0.23	0.12	0.18	0.41
Decomposition rate (k) of leaf litter[4]	1.94	1.63	1.58	2.09
$T_{1/2}$ (years)[5]	0.36	0.43	0.44	0.33

1 Based on Kojima (1980)
2 pH. Values were not different among the stands (randomization test with the bootstrap resampling
  (1000 times), P < 0.526)
3 Total N. Values were not different among the stands (randomization test with the bootstrap resampling (1000 times), P < 0.126)
4 Decomposition rate of leaf litter is caluculated from a negative exponential model: Wt/Wo =e-kt (Olson, 1963).
5 Half-life time (T1/2) for litter was calculated from the Olson equation.

Table 2. Relationship between structural attributes, sapling density and tree density in secondary forests and old growth forest.

| | Plot (age) | | | |
History	Stand-1 (15) Clear cut /Secondary	Stand-2 (30) Clear cut /Secondary	Stand-3 (50-100) Old Growth	Stand-4 (100<) Old growth
Tree density (m²)	2.99	1.52	0.92	0.84
Stand biomass (kg/m²)	9.44	15.93	22.27	23.92
Stand leaf mass (kg/m²)	0.39	0.56	0.64	0.64
Mean tree weight (kg)	3.1 ± 6.5	9.7 ± 20.5	23.9 ± 83.9	27.9 ± 133.7
Maximum tree height (m)	10	14.2	12.6	13.63
Sapling density of C. sieboldii(/m²)	0.05 (0.06)	0.23 (0.36)	0.82 (0.18)	0.78 (0.07)
Sapling density of other species (/m²)	3.75 (0.73)	0.73 (0.42)	2.51 (0.26)	5.82 (0.89)
Understory tree density of C. sieboldii (/m²)	0.29 (0.29)	0.16 (0.06)	0.01 (0.01)	0.02 (0.03)
Understory tree density of other species (/m²)	1.35 (1.00)	0.71 (0.40)	0.68 (0.08)	0.55 (0.12)
Understory tree density of C. sieboldii (/m²)	0.02 (0.01)	0.04 (0.07)	0.03 (0.02)	0.01 (0.03)
Understory tree density of other species (/m²)	0.02 (0.01)	0.03 (0.03)	0.08 (0.01)	0.05 (0.03)

Three life stages were defined for tree species: (i) canopy trees [DBH (stem diameter at breast height 1.3 m) > 10 cm]; (ii) understory trees (> 2 m in height and < 10 cm in DBH); and (iii) saplings (10 cm < height < 200 cm). Figures in parenthesis are the density of sprouting stems. Sapling, understory tree and canopy tree densities among stands were tested by Kruskal-Wallis test using grid based densities within each stand. Sapling and understory tree densities were significantly different among stands (P<0.001).

In the secondary forests (Stands 1 and 2) the size (DBH) structure of *C. sieboldii* showed almost bell-shaped distributions with positive skewness and bimodality (Fig. 2). The percentages of sprouting stems in the secondary forests were almost 40 %. In contrast, the old growth forests (Stands 3 and 4) showed inverse J-shaped DBH distributions. These DBH distributions significantly differed from one another (Kolmogorov-Smirnov two-sample test, $P < 0.025$). Sapling density of *C. sieboldii* was different among the stands. Most saplings of the seconday forests were sprouted ones, while those of the old growth forests were originated from seeds. Sapling density of the old growth forests were greater than those of the secondary forests (Table 2, Kruskal-Wallis test, $P < 0.01$).

However note that tree density in understory weakened in old growth stands. These differences imply the differences of regeneration and forest stratification in developmental stages.
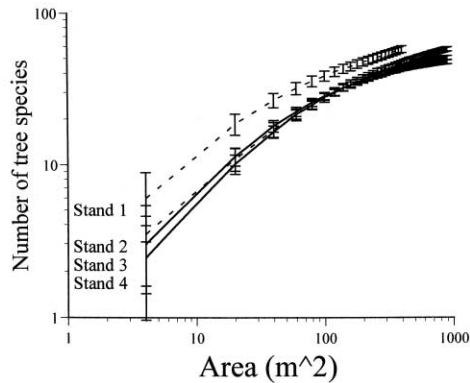
Fig.1. Relationship between the number of species and area in a subtropical forest, Okinawa Island, southern Japan. Subsampling was repeated 500 times for each subsample size. The number of species was averaged to determine as a function of size of the subsample. To compare species richness among the stands, two jackknife estimators were used (PALMER, 1990, 1991). Species richness estimated by jackknife estimators is shown in Table 3. Secondary forests (Stands 1 and 2) and old growth forests (Stands 3 and 4) are shown as broken lines and solid lines, respectively.

Table 3. Number of observed species (S), number of species estimated by the first order jackknife estimate (Jack1), number of species estimated by the second order jackknife estimate (Jack2), and species diversity indices of trees in 900 m2 plots of Yanbaru. Trees of which height was > 2.0 m. In order to avoid the sampling bias such as plot size, the D value was calculated at the 10 x 10 m subplot level, and then be averaged as a representative value at the plot level.

Plot	S	Jack1[(1)]	Jack2[(2)]	1-D[(3)]	H'[(4)]	J'[(5)]
Stand 1	56	73	83	0.924	4.501	0.772
Stand 2	53	70	75	0.891	4.027	0.721
Stand 3	49	57	56	0.935	4.612	0.821
Stand 4	48	51	51	0.952	4.831	0.870

(1) $Jack^1 = S + r_1*(n-1)/n$,

where S is the observed number of species, r_1 is the number of species occurring in one sample unit, and n is the number of sample units.

(2) $Jack^2 = S + r_1*(2n-3)/n - r_2*(n-2)2/(n*(n-1))$, where r_2 is the number of species occurring in exact two sample units (Palmer 1990, 1991).

(3) $$D = \sum_{i=1}^{s} \left\{ n_i (n_i - 1) / N(N-1) \right\}$$

(4) $$H' = -\sum_{i=1}^{s} P_i * \log_2 P_i$$

where n_i is the number of trees and P_i the relative frequency of trees of the i-th species in each plot.

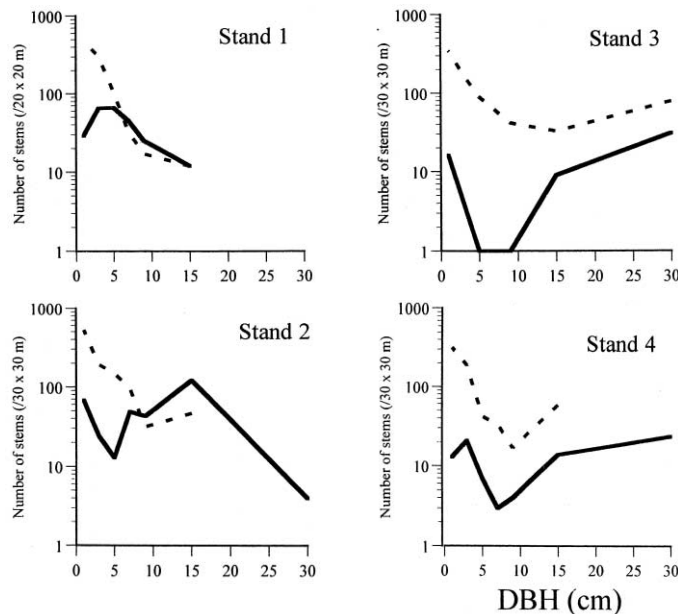(5) J = H /H max where H max = log2S,

Fig.2. Size (DBH: stem diameter at breast height 1.3 m) distribution of the most abundant
species, *Castanopsis sieboldii* (solid lines), and *other species* (broken lines) in each
plot. Stands 1 and 2 are forests of approximately 15 and 30 years, respectively. Stands
4 and 5 are old growth forest. See text and Table 1 for details.

Stand dynamics

A total of 895 seeds (38 seeds/m^2 yr) of *C. sieboldii* during 1998-2001 was counted in the
four plots. Stand 1 had no seed-rain for these four years. The total estimated seed productions over
all the four sites were 2, 17, 95, and 0 seeds/m^2 in 1998, 1999, 2000, and 2001, respectively. In
the old growth forests (Stands 3 and 4), seed production of *C. sieboldii* was significantly different
between years ($P < 0.05$, Repeated-Measures ANOVA). The largest seed production in 2000 was regarded
as a masting, and in this mast year, the density of seeds tended to be greater in the old growth
forests than in the secondary forests (Table 4), although the significant difference among Stands 2,
3, and 4 was not detected ($P > 0.05$, ANOVA). The old growth forests showed higher recruitment
rate of *C. sieboldii* than that of the secondary forests ($P < 0.001$ by randomization test)(Table 4).
Mortality of *C. sieboldii* and the other species at the stand level was not different among the
stands ($P > 0.09$ by randomization test).

Gain of stand biomass was smaller in the old growth forests, but their biomass lost to mortality
was larger than that of the secondary forests (Table 5). Most dead trees in the secondary forests
were standing dead and belong to small size classes. But in the old growth forests (Stands 3 and
4), high mortality was observed in the large size class, which was due to a typhoon in September
1999. As a result, above ground net primary productions (ANPP) as the sum of the amount of
litter fall, gain of stand biomass, and lost to predation, ranged from 1.19 kg/ha yr (Stand 3) to
1.57 kg/ha yr (Stand 1).

Table 4. Regeneration dynamics of subtropical forests based on seed dispersal, calculated recruitment and mortality of secondary forests and old growth forests.

History	Plot (age)			
	Stand-1 (15)	Stand-2 (30)	Stand-3 (50-100)	Stand-4 (100<)
	Clear cut /Secondary	Clear cut /Secondary	Old Growth	Old growth
Seed dispersal density of *C. sieboldii* (/yr, m²)*	0	1.5 ± 2.2	31.0 ± 41.8	5.5 ± 5.8
Recruitment rate of *C. sieboldii* (%/yr)[#]	0.85	1.44	3.34	6.31
Recruitment rate of other species (%/yr)[#]	2.01	1.21	1.30	1.64
Mortality rate of *C. sieboldii* (%/yr)[#]	2.51	5.24	3.34	7.16
Mortality rate of other species (%/yr)[#]	2.22	3.05	2.08	1.08

* Seed production in stand was investigated during 1997 - 2001, and values are the mean (+ S.D.) of four years. Differences between years and stands were tested by ANOVA.

Mortality and recruitment rates were estimated by using a logarithmic model of Condit et al. (1995), Sheil & May (1996), and Condit et al. (1999). Then siginificant difference was tested by randomization test with the bootstrap resampling (1000 times).

Table 5. Patterns of dynamical traits and net primary production in the subtropical forests, Okinawa Island, southern Japan.

History	Plot (age)			
	Stand-1 (15)	Stand-2 (30)	Stand-3 (50-100)	Stand-4 (100<)
	Clear cut /Secondary	Clear cut /Secondary	Old Growth	Old growth
Gain of stand biomass (kg/m², yr)	0.7954	0.6806	0.3825	0.4614
Loss of stand biomass (kg/m², yr)	0.0453	0.1274	0.1232	0.5090
Growth of stand biomass (kg/m², yr)	0.7501	0.5532	0.2593	-0.0476
Litter fall (kg/m², yr)	0.76 ± 0.08	0.72 + 0.05	0.78 + 0.25	0.89 + 0.12
Loss of stand biomass by predation (kg/m², yr)	0.0153 ± 0.0006	0.0281 ± 0.0095	0.0253 ± 0.0074	0.0243 ± 0.0016
Net primary production* (kg/m², yr)	1.5707	1.4287	1.1878	1.3757

* Above ground net primary production of stand biomass (ANPP) was calculated based on the method of Clarki et al. (2001), the sum of the amount of fine litterfall , increment of stand biomass, and lost to consumers.

Tree growth and competition

The results of non-linear regression analysis with Quasi-Newton method are shown in Fig.3. All the three parameters in the logistic growth function were different between *C. sieboldii* and

the other species regardless of the stand ages. Population of *C. sieboldii* had larger *a* (0.33 - 0.74) in the logistic growth function, which means the upper limits of absolute growth rate, than that (0.13 - 0.46) of any other species (Fig. 3)($P < 0.0001$ by Log likelihood ratio test between *C. sieboldii* and the other species in each stand), implies that individual trees of *C. sieboldii* grew faster, especially in the canopy. Also the three parameters differed among the stands ($P < 0.0001$ by Log likelihood ratio test based on pair-wise among the three parameters in the stands). The non-linear regression by the logistic function gave higher r^2-values in the secondary forests than those in the old growth forests. For *C. sieboldii* in the secondary forests (Stands 1 and 2), the growth rates of DBH indicate strong size-dependent growth patterns. On the other hand, the old growth forests (Stands 3 and 4) showed size-dependent asymptotic growth patterns with large variances (1 - $r^2 > 0.73$).

Competitive effects on individuals were detected at 5 m neighborhood radius, rather than at 2
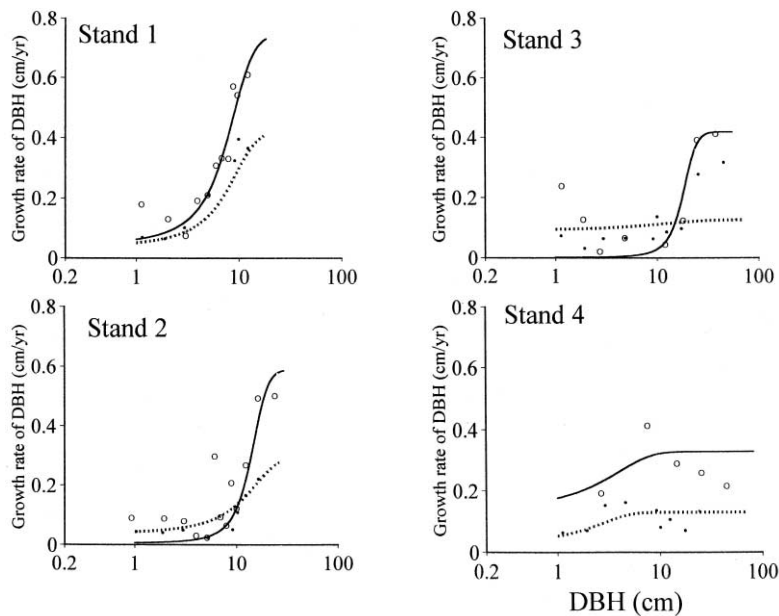

Fig.3. Relationships between DBH and absolute growth rate of *DBH* for individual trees of *Castanopsis sieboldii* (solid lines and open circles) and *other species* (broken lines and solid circles). Individual stems of Stand 1 and 2 are divided into DBH size class at 1- and 5cm intervals, whereas those of Stand 3 and 4 at 1-, 5- and 10-cm intervals so that each DBH class contains at least about 10 stems. The function form of the relationship between DBH (*x*) and absolute growth rate (*y*) is given as logistic growth model:

Stand 1, *C. sieboldii,* $y = 0.74/(1 + 15.95*exp(-0.38*x))$ ($r^2 = 0.43$),
  other species, $y = 0.42/(1 + 10.05*exp(-0.32*x))$ ($r^2 = 0.22$);
Stand 2, *C. sieboldii,* $y = 0.76/(1 + 24.39*exp(-0.19*x))$ ($r^2 = 0.47$),
  other species, $y = 0.46/(1 + 10.73*exp(-0.15*x))$ ($r^2 = 0.05$);
Stand 3, *C. sieboldii,* $y = 0.50/(1 + 888.55*exp(-0.32*x))$ ($r^2 = 0.27$),
  other species, $y = 0.38/(1 + 7.67*exp(-0.09*x))$ ($r^2 = 0.05$);
Stand 4, *C. sieboldii,* $y = 0.33/(1 + 1.34*exp(-0.42*x))$ ($r^2 = 0.03$),
  other species, $y = 0.13/(1 + 3.17*exp(-0.77*x))$ ($r^2 = 0.08$).

Fitting of this model was conducted for absolute growth rate of each stem as the dependent variable and DBH as the explanatory variable for each of *C. sieboldii* and *other species*.

m or 3 m radii, which is almost consistent with the distance (max. 5.8 m) of the crown spread for canopy trees of *C. sieboldii*. In the following, therefore, only the results of 5 m radius were discussed below. The mode and the intensity of intra-and inter-specific competition are shown in Table 6. These effects are assessed by the *P* level and 95 % confidence limits based on the randomized simulations. At first, multiple linear regression analysis was conducted using the forward stepwise method at *P* < 0.05. Competitive effects were expressed as the coefficients of the model between Freedman-Turkey-transformed DBH growth rate of each individual tree as the dependent variable, and log-transformed DBH and crowding indices of *C. sieboldii* and the *other species* as the Table 6.

Table 6. Intra- and Inter-specific competitive effects among species on the growth rate of DBH of individual trees of secondary forests and old growth forests.

	Inter-specific competition		Intra-specific competition	
	From *C.sieboldii* to other species	From other species to *C.sieboldii*	Between trees of *C.sieboldii*	Between trees of other species
Stand 1 (secondary)	ns (-0.016 ∼ -0.169)	-0.202* (-0.001 ∼ -0.503)	-0.313*+ (-0.130 ∼ -0.309)	-0.240* (0.086 ∼ -0.240)
Stand 2 (secondary)	ns (-0.016 ∼ -0.182)	-0.320* (-0.063 ∼ -0.401)	-0.570*+ (-0.414 ∼ -0.543)	-0.216* (-0.065 ∼ -0.229)
Stand 3 (old growth)	-0.122* (0.07 ∼ -0.133)	-0.602*+ (0.208 ∼ -0.529)	ns (0.195 ∼ -0.290)	ns (-0.018 ∼ -0.123)
Stand 4 (old growth)	ns (0.089 ∼ -0.108)	-0.400*+ (0.232 ∼ -0.200)	ns (0.201 ∼ -0.186)	ns (.0.141 ∼ -0.097)

Multiple linear regression abalysis was conducted. The DBH increment as the dependent variable was Freedman-Tukey transformed to have a constant variance of residuals.

* Denote significant values at P < 0.05 based on the multiple linear regression analysis.

+ Denote values out of random at 95 percent based on the randomized simulation.

Figures in parenthesis are 95 percent confidence intervals for competitive coefficients calculated from the nineteen simulations using the random point process.

explanatory variables. Then these coefficients were compared with 95 % confidence limits of that coefficient generated by multiple linear regression analysis using randomized dispersion of individual trees. Like this procedure is more accurate/conservative to ascertain the mode/intensity of competition.

As a result, the mode of competition was quite different among the four stands. In the secondary forests (Stands 1 and 2), *C. sieboldii* showed the evidence of intraspecific competition, although competition in Stand 1 was weak (because the competitive effect among *C. sieboldii* trees was almost equal to the highest value of that generated by randomized dispersion of individual trees). Interspecific competitive effects of the *other species* on *C. sieboldii* and intraspecific competitive effects within the *other species* trees were smaller than 95 % confidence limits calculated by the randomized simulations. In the old growth forests (Stands 3 and 4), interspecific competition of *C. sieboldii* was detected. Intraspecific competitive effects of *C. sieboldii* or *other species* were not entered into the regression, indicating the growth of *C. sieboldii* was regulated by *other species*.

POPULATION STRUCTURE AND GROWTH DYNAMICS OF CASTANOPSIS SIEBOLDII
IN SECONDARY-AND OLD GROWTH-SUBTROPICAL FORESTS IN SOUTHERN JAPAN

Discussion

OLIVER (1980) and OLIVER and LARSON (1996) proposed a conceptual model describing the reconstruction process from establishment, thinning, and transition to the steady state following disturbances, based on the dendrochronology of individual trees in a cool-temperate forest. DENSLOW and GUZMAN (2000) investigated the variation of stand structure in a tropical moist forest according to the 4-phase model of the secondary succession: stand initiation, stem exclusion, understory reinitiation, and old growth. In short, the debate on the development process of forests is often based on the chronosequence of plots of various stand ages (FOSTER, 1990, BROWM & LUGO, 1990, KITAYAMA et al., 1995, GRAU, et al., 1997, STEININGER, 2000), which is feasible rather than monitoring stand development over several decades.

In this study, although trees of *C. sieboldii* in the secondary forests have just reached the reproductive stage, the understory of the stands was not fully reinitiated (e.g., lower recruitment rate of *C. sieboldii*)(Table 4), thus the secondary forests developing following clear cutting seem to be in a relatively early developmental phase. We could find a symptom of reinitiation in Stand 2, which had a little amount of seed production and saplings originated from seeds. On the other hand, the old growth forests had the inverse J-shaped DBH distributions and the high sapling density, can be realized at a late developmental phase with understory reinitiation (e.g., higher recruitment rate of *C. sieboldii*). If we use assumptions of a chronosequence analysis to demonstrate structural and dynamical differences between the secondary and old growth forests, it might be possible to illustrate regeneration dynamics over stand development, like those described in previous studies. Note that this does not necessarily indicate that these stands developed as a "successional continuum" in terms of species composition.

High density forests with small mean above-ground biomass (Stands 1 and 2) are at an early developmental stage, while low-density forests with high biomass (Stands 3 and 4) are mature. Moreover *C. sieboldi* is a dominant species throughout developmental phases, determining the canopy structure of the subtropical forests (c.f., SHIMIZU et al. 1988). These results imply that stand biomass composed of *C. sieboldii* and a variety of subordinate species develops with competition such as self-thinning among trees (YODA et al., 1963). In order to reveal the community dynamics, it is reasonable to examine the mode of competition between *C. sieboldii* and the *other species*. For example, YAMAMOTO (1994) suggested that population structure of *Castanopsis* spp. shifts to the regeneration niche of a pioneer species, due to interspecific competition of *Distylium racemosum* co-occurring in the late developmental stage.

Our present study showed that competitive effects and growth patterns are different among developmental phases of forests (KOHYAMA, 1987). In particular, canopy trees of *C. sieboldii* in the secondary forests grew faster than those of any other species (Fig. 3). This enables the cohort of *C. sieboldii* to regenerate in open sites and to reach the canopy quickly, undergoing intraspecific competition (that may be attributable to the high density of sprouting stems)(Table 2). Thus, relatively high ANPP (Table 5), which is comparable to that of montane tropical forests reviewed by CLARK et al. (2001b), seems to reflect on growth and sprouting abilities of *C. sieboldii*.

In the late developmental stage, however, *C. sieboldii* gave no indication of intraspecific competition, and interspecific competition prevailed, which suggests that *C. sieboldii* is regulated by suppression from other species. In the old growth forests, weak domination of *C. sieboldii* in the understory [despite plenty of seed dispersal, sapling density and recruitment (Table 2, 4)] may be a result of the severe interspecific competitive effects from canopy trees of *other species* to understory trees of *C. sieboldii*. Comparison between the secondary forests and the old growth forests reveals a

trend toward the steady state with gap disturbance which plays a role in regeneration dynamics of understory trees. For example, the growth rate of biomass decreased with increasing stand age (Table 5). This may be explained by the reason that the gain of stand biomass is canceled by the loss of biomass due to gap disturbances, especially in the old growth stand. This is also reflected by weak size-dependent growth with a large variance of *C. sieboldii* in the old growth forests, which may be caused by heterogeneity in terms of light environment (Fig. 3). The present results suggest that relatively high species diversity in the old growth stands can be maintained by competitive effects of the *other species*, which reduces the monopolization of *C. sieboldii*, and by gap disturbances which gives opportunities of regeneration for the *other species*.

In conclusion, structural attributes and growth dynamics showed different patterns between the secondary and the old growth forests, although the observed patterns qualitatively differ only among the four stands. Variation in the mode and the intensity of competition may reflect on the degree of the heterogeneity of the stand structures through the forest development, and the shifting from intra- to inter-specific competition, which probably associates with the spatial structure of trees. Because spatial dispersion such as clustering/regularity of individual trees has a large influence on detectability of competitive effects among individual trees [reported in detail in a following paper (SHIMATANI & KUBOTA, manuscript in review)]. Compositional convergence representing the domination of *C. sieboldii* with a variety of subordinate species can be understood as the combined effect of stand structure and the mode of competition.

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SIZE COMPOSITION OF SEA SURFACE CHLOROPHYLL *a* CONCENTRATION IN KAGOSHIMA BAY

Toru KOBARI, Akimasa HABANO and Toshihiro ICHIKAWA

Abstract

Size fractionated chlorophyll *a* concentrations at sea surface were investigated from May 2001 to May 2002 at the two stations in the inner and center area of Kagoshima Bay. Chlorophyll *a* concentrations in the inner area were much higher than those in the center area. Highly fluctuated chlorophyll was observed at both stations and was resulted from a rapid increase of micro-sized phytoplankton. Pico- and nano-sized phytoplankton were more predominated in the center area, although micro-sized phytoplankton was abundant in the inner area.

Keywords: Size composition, Chlorophyll *a* concentration, Kagoshima Bay

Introduction

Kagoshima Bay is a large semi-enclosed bay located at the southernmost of Kyushu, southwestern Japan. Although nutrient-poor waters, Kuroshio water, are influential in the center area, water exchange is highly limited in the inner area because of narrow and shallow channel and depth more than 100 m. Thus, size composition of phytoplankton is important. In the present study, we investigate size composition of chlorophyll *a* concentration at two different areas in Kagoshima Bay.

Materials and Methods

Oceanographic observations and water samplings were weekly to biweekly carried out from April 2001 to May 2002 during T/S *Nansei-Maru* cruises. Sampling stations were conducted around the deepest parts of the inner and center areas (Fig. 1). Depth was 225 m at Station 10 and 135 m at Station 23, respectively.

Water temperature was determined with a thermometer at sea surface and a reversing thermometer attached with Nansen bottle at other depths. Water samples for chlorophyll *a* concentrations were taken using a plastic bucket. Each water sample (200-1000 ml) was filtered through plankton net (mesh opening: 20 μm) and Whatman GF/F filter (pore-size: 0.7 μm). From mid-November, Millipore JM membrane filter (pore-size: 5 μm) was also used. Chlorophyll pigments on the filters were extracted in n, n-dimethylformamide (SUZUKI & ISHIMARU, 1990). Chlorophyll extraction was made by direct immersion of the filters into the solvent at -5.5 under dark condition overnight. Chlorophyll *a* concentration was measured with Turner Designs fluorometer (TD-700) by fluorometry (HOLM-HANSEN et al., 1965).
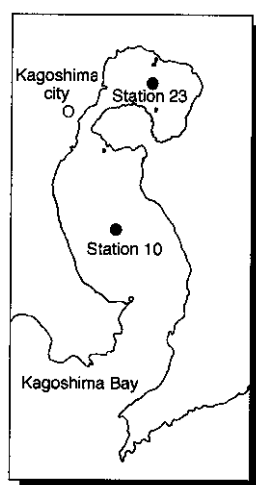
Fig.1. Sampling stations in Kagoshima Bay, southwestern Japan.

Results and Discussion

Temperature

    Water temperature at both stations showed a similar pattern (Fig. 2).   Surface temperature increased above 28   from July to August and made a large difference of temperature at other depths.   Sea surface temperature was reached maximum in early August, and was 30.7   at Station 10 and 31.0   at Station 23, respectively.   Surface temperature decreased after October and no stratification occurred from January to March.

Minimum sea surface temperature was 15.2   at Station 10 in January and 14.4   at Station 23 in February, respectively.   Bottom temperatures were near constant at 15   at Station 10 and 17   at Station 23 throughout the year.
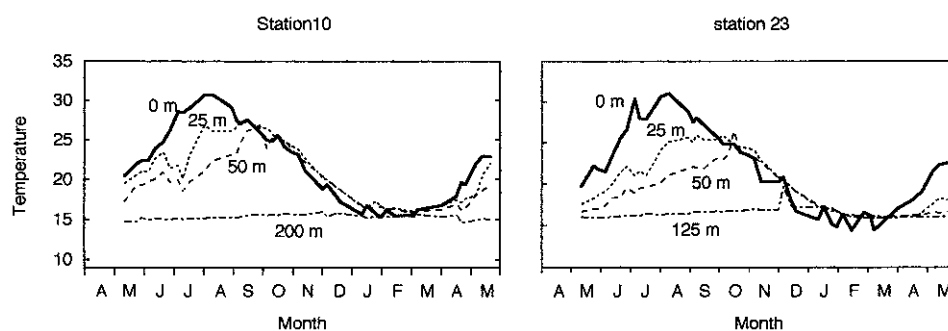
Fig.2. Seasonal changes in temperature (   ) at sea surface, subsurface (25 and 50 m)
       and near-bottom from 2001 to May 2002 in the center area (Station 10: left)
       and in the inner area (Station 23: right).

Size composition of chlorophyll a

Sea surface chlorophyll *a* concentrations at Station 23 were much higher than those at Station 10 (Fig. 3). Highly fluctuated chlorophyll was observed at both stations and was associated with a rapid increase of micro-sized phytoplankton. Because actively growth of large phytoplankton have been well known in the nutrient-rich waters (PARSONS et al., 1984), there might be spontaneous nutrients input from the rivers caused by rainfall throughout the year. However, seasonal variation patterns were pronounced for micro-sized phytoplankton and they were predominated in May to June, October to December, and February to March. On the other hand, pico- and nano-sized phytoplankton were abundant in July to September, January to February, and April to May. In general, small phytoplankton was more predominated in the center area, although large phytoplankton was abundant in the inner area. According to the results of ICHIKAWA et al. (1999), the volcanic ashes from Mt. Sakurajima accelerated the formation and downward export of large particles in Kagoshima Bay. These results suggest that large amounts of phytoplankton are exported downward as a carbon source without grazing and decomposing by zooplankton. Considering the limited water exchange and the predominant of large phytoplankton in the inner area, excess nutrients input might rapid accelerate not only harmful algae bloom in the surface but also depletion of oxygen at the near-bottom.
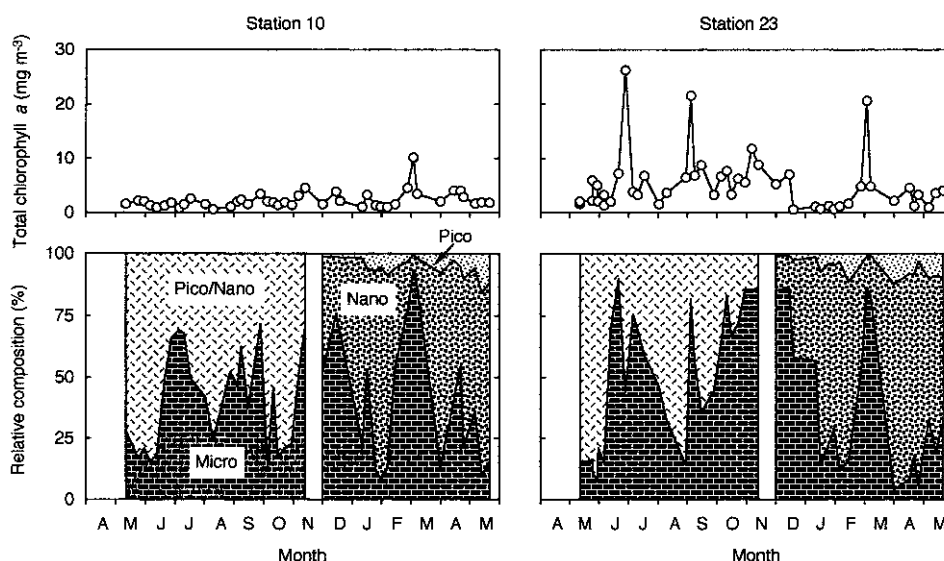
Fig.3. Seasonal changes in sea surface chlorophyll *a* concentrations (mg m^{-3}) and relative composition of pico-, nano- and micro-sized phytoplankton from May 2001 to May 2002 in the center area (Station 10: left) and in the inner area (Station 23: right).

Acknowledgements

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A TRANSECT STUDY IN THE INFRA-LITTORAL ZONE OF HAKAMAGOSHI — AN ASSESSMENT OF THE IMPACT OF CONSTRUCTION OF A MAN-MADE SAND BEACH

Shusuke ONO, James Davis REIMER and Junzo TSUKAHARA

Abstract

The infra-littoral zone of the Taisho Lava Field at Hakamagoshi, Sakurajima has strong tidal and ocean currents, which, when combined with volcanic rock from the lava flow, result in the presence of an abundance of soft corals and other marine life (ONO & TSUKAHARA, 2000, ONO et al., 2002). To investigate the effects of the new man-made sand beach at Hakamagoshi on marine life in the surrounding marine environment, a transect survey has been conducted, along with core samples. Our results show this abundance is relatively unchanged since the recent construction in the area. Core samples from our survey are also typical of other core samples taken at Hakamagoshi, showing that construction influences on the seafloor were yet to be seen as of the time of this survey. A longer-term study with more data should help clarify the impact of construction on the Hakamagoshi inter-tidal zone.

Key words: Sakurajima, Hakamagoshi, Man-made sand beach, Infra-littoral zone, Transect survey, Sediment composition

Introduction

The infra-littoral zone of the Taisho Lava Field at Hakamagoshi, Sakurajima has strong tidal and ocean currents, which, when combined with the volcanic rock from the lava flow, results in the presence of an abundance of soft corals and other marine life (ONO & TSUKAHARA, 2000, ONO et al., 2002). However, the north part of Hakamagoshi includes a harbor with ferries that connect Sakurajima with Kagoshima City. Recently, construction and add-ons in this area have proceeded at a rapid pace. In June 2000 a new National Resort Inn (Kokumin Shukusha) on the waterfront at Hakamagoshi was opened (Fig. 1), and a complementary man-made sand beach swimming area was opened next to the Inn in March 2002 (Fig. 2).

Similarly, several years ago, across Kagoshima Bay, at Iso Beach in Kagoshima City, a large amount of sand from different areas was brought in to enlarge Iso Beach. Ocean currents carried this extra, ″imported″ sand to the surrounding infra-littoral area, resulting in the covering, decrease and/or disappearance of large numbers of marine life (Kubota, personal communication). From this experience, it is thought that man-made sand beaches have a drastic and debilitating effect on nearby infra-littoral ecosystems.

To investigate the effects of the new man-made sand beach at Hakamagoshi on marine life in the surrounding marine environment, a transect survey has been conducted, along with core samples.
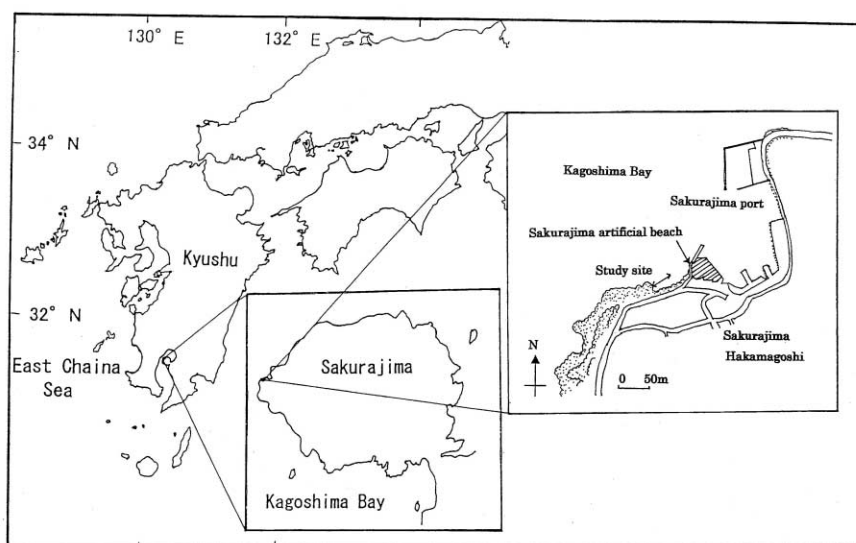
Fig.1. Map of study site: Taisho Lava Field, Sakurajima, Kagoshima, Japan.
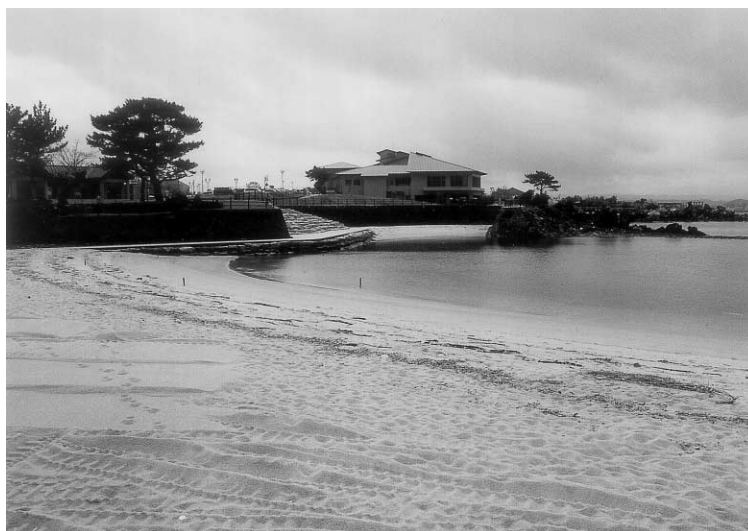
Fig.2. Man-made sand beach swimming area opened next to the National Inn in March 2002.

Materials and Methods

Transect Survey

As shown in Figure 1, the area of study was the beach and infra-littoral area directly in front of the National Resort Inn. This field site is located approximately 200m south of the newly constructed sand beach swimming area. The survey was conducted on April 14, 2001. The line transect survey

was conducted as explained in LOYA and SLOBODKIN (1971) and LOYA (1972). The area of the survey was from the extreme low tide line straight out from shore 40m. Every 10m along this line (at 10, 20, 30, and 40m from shore) a 10m line was drawn centered on the line from shore, extending out perpendicular 5m on either side from the line. All soft coral, anemones, hard corals, and other species present along these lines were noted. As well, seawater temperature, depth, and visibility were noted as the survey was being done. Photographs were taken with an underwater camera to help double check survey results at a later date.

Core Samples and Sediment Composition

To investigate the composition of the seafloor of the survey site, 3 core samples were taken during the survey at three spots along the transect line extending from shore. Core samples at 13m (depth 3m), 27m (depth 6m), and 40m (depth 9m) were taken. Core samples were placed in 5 % formalin seawater, and analyzed by the Emery settling-tube method.

Results

Because the Taisho Lava Field at Hakamagoshi is relatively new (produced in 1914 by the big eruption named Taisho Dai-funka), the terrain of the field site is quite rough, with many grooves and bumps (see Figure 3). Much marine life can be seen on the various outcroppings and rocks.
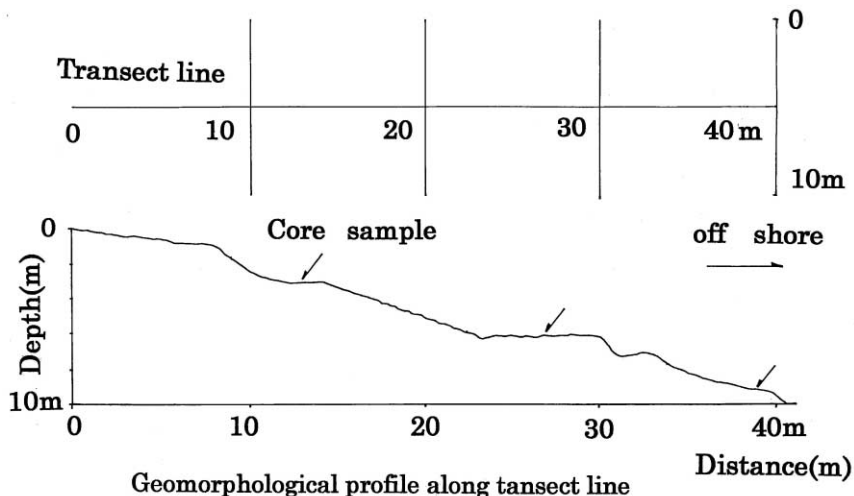
Fig.3. Geomorphological profile along the base line from shore and the profile of the transect line.

(1) Line Transect Study Results

Line transect study results are shown in Figure 4.

From the extreme low tide-line to 10m, the seafloor reaches a depth of 3m. Marine life covered 29% of the transect at 10m, consisting largely of *Antheopsis, Entacmaea, Zoanthus, Stereonephythya*, and *Pavona*.

From 10 to 20m, depth reached 5m, and marine life cover was 27% at 20m, consisting of *Antheopsis, Zoanthus, Stereonephythya, Faviidae, Pavona*, and the table coral *Acropora*.

From a distance of 20 to 30m, the ocean floor dropped to 6.5m, and marine life cover reached 35%. *Lithophyllon* cover alone consisted of 13% cover. As well, *Faviidae, Pavona, Porites, Entacmaea,* and *Zoanthus. Stereonephythya*, which was extremely common near shore (especially at 10m distance) was not seen at all.

The seafloor between 30 and 40m reached a depth of 9m, and largely consisted of sediment. Accordingly, marine life cover was much lower than the other transect areas at only 17%, with the number of colonies 10 less than any other 10m line. *Faviidae, Lithophyllon, Montipora,* and *Pavona* were all relatively common.

When compared to data collected by ONO and TSUKAHARA (2000) and ONO et al. (2002) for this field site over the last 20 years, the % cover is generally lower than what is usually seen, but overall the results are quite similar.
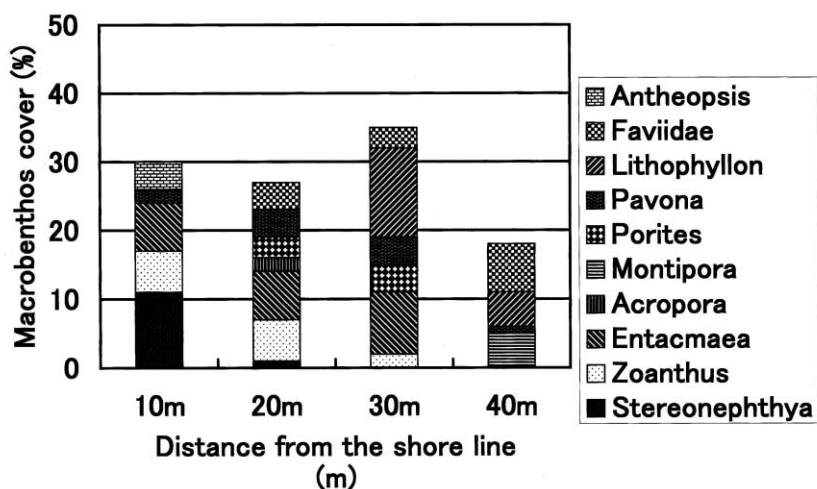
Fig.4. Macrobenthos cover each transect lines.
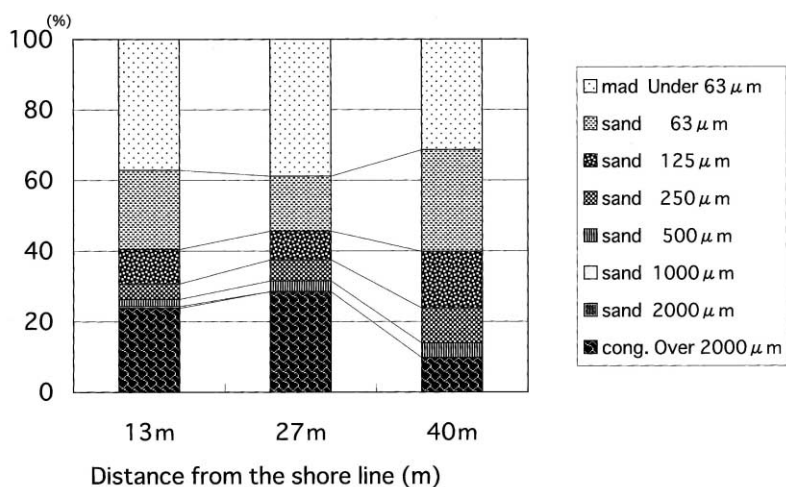
Fig.5. Sediment composition from all three locations. Axis of ordinates is grain size ratios of bottom sediment at each station. cong.: conglomerate

(2) Core Sample and Sediment Composition Results

Core samples from all three locations showed little change in the amount of mud present (see Figure 5). The amount of sand was much greater at the third sampling location (40m from shore) than at either of the two locations closer to shore.

In the future investigation of the influence of typhoons and strong wind and wave action on the sand beach and the surrounding study area is planned.

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衛星データを用いた屋久島の環境モニタリング

要　　旨

30m x 30m

L-5/TM

NDVI$_{NC}$　　　　　　　　NDVI$_{AC}$　　　　　　B4$_{GC}$

キーワード：

ENVIRONMENTAL MONITORING ON YAKU ISLAND USING SATELLITE DATA

Etsuji Ishiguro   and   Mitsunori Simosakaida

Abstract

As the Earth environment has been changing drastically, the development of monitoring technique has been become important and required. We focused to estimate the standing tree volumes because of that tree are absorption of carbon dioxide. For measuring the tree standing tree volume, ground truth and air photo has been used, traditionally. However former method was required huge human power and risks and latter method was very expensive and skill.

This study focused to develop the easy method to estimating these tree volumes using satellite data. Ground truth data and processed satellite image data were compared to clarify the accuracy.

Key words: Yaku island, Remote sensing, Landsat, Tree volume, Environmental monitoring.

はじめに

供試材料ならびに解析方法

供試材料
1 解析対象地

km   k   km

km   km

m   m

mm

2 供試衛星データ

Landsat/TM   SPOT/HRV   NOAA/AVHRR

Landsat-5/TM   L-5/TM

3 供試現地調査データ

解析方法
1 幾何補正

ERDAS IMAGINE   Ground Control Point (GCP) Editor

Root Mean Square Error: RMS Error

GCP

Total RMS Error　　　pixel　　　　　　　　　　　　m　　x　　m

2　大気補正

L-5/TM

LP(　)　　　　　　　　　　　　　　　　　　　　　　L-5/TM

			m³	m³	
			·	·	·
			·	·	·
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			·	·	·

3　解析指標
１）：NDVI

nm

n　　nm　　　　　　　　　　　　　　　　　　nm　　　　nm

Normalized Difference Vegetation Index: NDVI

NDV　　　NDVI$_{NC}$

NDVI　　　NDVI$_{AC}$

２）：B４$_{GC}$

L-5/TM　　　　　　　　　　　　　　　　　　　　Band

NDVI$_{NC}$　　　　　　　　　　　　　　　　　L-5/TM

Band4　　　　　　　　　　B4$_{GC}$

Band2 +Band3 +Band4

B4$_{GC}$ =B4/(B2+B3+B4)

L-5/TM

ERSDAC(Earth Remote Sensing Data Analysis Center)

Navigator　　　E-Navi

4　解析結果の検証

120m x120m (4pixel x 4pixel)

E-Navi　　　　　　　　　　　　Dibas

Photoshop

１）：単回帰分析

B4$_{GC}$

２）：重回帰分析

NDVI

結果及び考察

1　L-5/TMデータの幾何補正

L-5/TM　　　　　　　　　　　　L-5/TM　　　Band2　　　　Band3

Band4　　　　　　　　　　　true color

UTM

pixel　　　　　　　　　　　　　　　m(=0.3x 30m)

L-5/TM

2　Ｌ−５／ＴＭデータの大気補正

LP(　)

L-5/TM

NDVI

	B	B	B	B	B	B	B
／　／							
／　／							
／　／							
／　／							

3　解析指標
１）　NDVI画像

NDVI

NDVI$_{AC}$

NDVI

NDVI

NDVI

NDVI

$NDVI_{AC}$

$NDVI_{NC}$

２） Ｂ４$_{GC}$画像

$B4_{GC}$　　　　NDVI

$B4_{GC}$

$B4_{GC}$

４　解析結果の検証
１） 単回帰分析

$B4_{GC}$

$B4_{GC}$　　　　　　　　　　　　　$B4_{GC}$
L-5/TM

$B4_{GC}$　$NDVI_{AC}$　$NDVI_{NC}$

２） 重回帰分析

$B4_{GC}$

L-5/TM

L-5/TM

NDVI

L-5/TM   B4$_{GC}$ NDVI$_{AC}$ NDVI$_{NC}$

NDVI$_{NC}$ NDVI$_{AC}$
B4$_{GC}$ L-5/TM
NDVI$_{AC}$ B4$_{GC}$
B4$_{GC}$

総　括

30m x 30m   L-5/TM
NDVI$_{NC}$
NDVI$_{AC}$ B4$_{GC}$

NDVI

L-5/TM

NDVI$_{AC}$ B4$_{GC}$ B4$_{GC}$

1m x 1m   IKONOS

謝　辞

文　献

Landsat/MSS　TM

⑷

⑵
Landsat　TM

⑴

DISTRIBUTION CHARACTERISTICS OF POLYMORPHIC ALLELES AMONG THE POPULATIONS OF THE NANSEI ISLANDS, JAPAN

Kazutoshi Ago

Abstract

The characteristics of the distribution of blood group polymorphism alleles among the populations of the Nansei Islands, Japan, were examined using currently available blood group data, such as red cell types, enzyme types and serum protein types. 1. A comparison of genetic diversity was made between the Amami-Oshima and Tanegashima populations, and the neighboring large populations such as the mainland of Kagoshima and the main island of Okinawa. Gene diversity in the island populations is similar to that of Kagoshima and Okinawa. 2. Geographical clines of allele frequency of blood groups in Japanese populations are discussed. Clines constructed using the Nansei Islands data support the 'dual structure model' hypothesis for the origin of the Japanese more strongly than previously described clines. 3. Two rare alleles, TF Damami and AHSG 5, which are uniquely distributed in the Nansei Islands, are described.

Key words: Nansei Islands, Island population, Blood groups, Geographical cline

Introduction

The Nansei Islands form an archipelago stretching between the mainland of Kagoshima and Taiwan, and are potentially important in tracing the origin of the Japanese people. I investigated the distribution of blood group alleles with the purpose of revealing the genetic characteristics of this area and to gather basic data for forensic practices. In this paper, on the strength of the data accumulated so far, I discuss the genetic homogeneity of the Tanegashima and Amami-Oshima populations, geographical clines of allele frequencies in Japanese populations and rare variants distributed specifically in the Nansei Islands.

The Genetic Homogeneity of Tanegashima and Amami-Oshima Populations

Gene diversity, meaning the degree of genetic homogeneity in each population, was calculated by the following equation (ROYCHOUDHURY & NEI, 1988) using the available data (AKAISHI & KUDO, 1975; ISHIMOTO, 1975; OMOTO, 1975; ROYCHOUDHURY, & NEI, 1988, AGO et al., 1998a, b).

$$H = 1 - \sum_{i=1}^{k} xi2$$

where xi is the frequency of the i-th allele in the population and k is the number of alleles. Comparison of gene diversity among populations from Amami-Oshima, the mainland of Kagoshima and the main island of Okinawa was carried out using eight blood group loci. As shown in Table 1, the average value of the Amami-Oshima population (0.415) laid between those of the Kagoshima and Okinawa populations (0.4064 and 0.4189 respectively) and statistically significant differences were not observed. The average value of the Tanegashima population (0.5044) was also similar to those of populations

from Kagoshima, Amami-Oshima and Okinawa (0.4950, 0.5157 and 0.5054 respectively), as shown in Table 2, and there are also no statistically significant differences. These results indicate that Amami-Oshima and Tanegashima have sufficiently large populations to maintain allele heterogeneity and avoid island effects usually associated with isolated populations. Similar investigations on islands with small populations, such as Yakushima, Okinoerabu and Yoron, are necessary, but data from these areas are not currently sufficient to allow detailed analysis.

Table 1. Comparison of gene deversity between Amami-oshima and neighboring populations.

	Amami-oshima	Kagoshima*	Okinawa
GC	0.6574±0.0075	0.6506±0.0084	0.6578±0.0080
TF	0.3998±0.0084	0.3693±0.0145	0.3942±0.0119
AHSG	0.4213±0.0156	0.3754±0.0147	0.3913±0.0120
HP	0.3565±0.0091	0.4009±0.0119	0.3752±0.0094
AP	0.3482±0.0176	0.3523±0.0135	0.3960±0.0114
PGD	0.1130±0.0160	0.1440±0.0134	0.1456±0.0126
PGM1	0.4234±0.0141	0.3743±0.0130	0.4125±0.0120
ABO	0.6003±0.0081	0.5846±0.0012	0.5782±0.0014
Average	0.4150±0.0586	0.4064±0.0545	0.4189±0.0536

*:the mainland of Kagoshima

Table 2. Comparison of gene deversity between Tanegashima and neighboring populations.

	Tanegashima	Amami-oshima	Kagoshima*	Okinawa Honto
GC	0.6359±0.0102	0.6574±0.0075	0.6506±0.0084	0.6578±0.0080
TF	0.4013±0.0124	0.3998±0.0084	0.3693±0.0145	0.3942±0.0119
AHSG	0.3959±0.0120	0.4213±0.0156	0.3754±0.0147	0.3913±0.0120
ABO	0.5845±0.0074	0.6003±0.0081	0.5846±0.0012	0.5782±0.0014
Average	0.5044±0.0620	0.5197±0.0642	0.4950±0.0721	0.5054±0.0670

*:the mainland of Kagoshima

Geographical Clines of Allele Frequencies in Japanese Populations

The 'dual structure model' of HANIHARA (1991), describing the origin of the Japanese people, is currently thought to offer a reasonable explanation. It is thought that the modern Japanese consist of the Ainu and Ryukyus peoples descended from the Jomon people and the Hondo Japanese, who mixed with immigrants from the Korean Peninsula during the Yayoi era. Therefore, differences in genetic traits exist in the eastern and western parts of the Japanese Islands. Geographical clines in allele frequencies have so far been reported in the ABO system (FUJITA et al., 1978), the GPT type (a red cell enzyme type; ISHIMOTO & KUWATA, 1974) and the GC type (a serum protein type; YUASA et al., 1983). It is thought that these clines provide evidence in support of the differences in genetic traits mentioned above. In previous studies, clines starting from northern regions, such as Aomori, were examined. However, if genetic traits were influenced by immigrants from the

Korean Peninsula, clines starting from western areas, such as the northern part of Kyusyu, Yamaguchi and Kinki, should be examined. As shown in figure 1 for the clines of the ITI alleles, two types of cline originating from Aomori and Yamaguchi were examined. Linear clines originating from Aomori similar to the ABO, GPT and GC clines described in previous reports were observed (figure 1A). Clines from Yamaguchi, shown in figure 1B, demonstrate that different clines exist in the eastern and western parts of the Japanese Archipelago (AGO et al., 2000). V-shaped and inverted V-shaped clines were similarly observed in the GC and TF types (AGO et al., 1998a, b), adding further support to the' dual structure model' hypothesis.
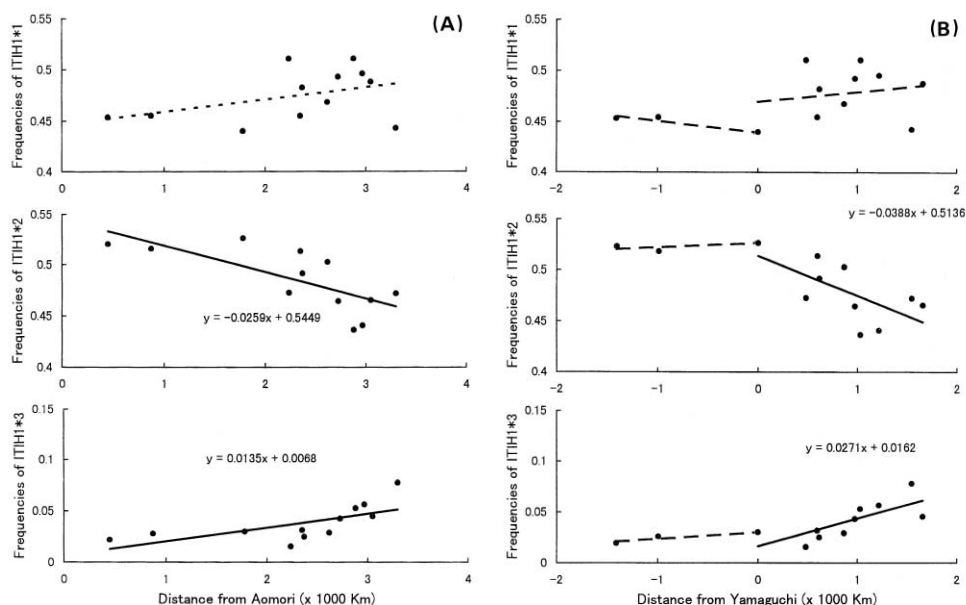

Fig.1. Geographical clines of ITI gene frequencies in Japanese populations. Distances were measured from Aomori in (A) and from Yamaguchi in (B).

Rare Variants Specifically Distributed in the Nansei Islands

I discovered that two rare alleles, TF Damami (AGO et al., 1998a) and AHSG 5 (TAMAKI et al., 1996) appear to be distributed exclusively within the Nansei Islands. As for the above mentioned TF type, three phenotypes, TF C1, TF C1C2, TF C2, which are controlled by the TF C1 and TF C2 alleles, were commonly observed in Japanese populations. Rare variants controlled by the TF B and TF D alleles were also observed. These phenotypes are shown in figure 2. Most of the TF D variants in Japanese populations are TF Dchina. In Amami-Oshima, a TF D variant, tentatively named TF Damami, was frequently observed. TF Damami was also observed in each sample from Yakushima and Okinoerabu. TF Damami moved slightly faster than TF Dchina on the electrophoretogram shown in figure 2. In the AHSG type (a serum protein type) AHSG 1 and AHSG 2 are common alleles. The AHSG 5 allele is extremely rare throughout most of Japan, but not in Amami-Oshima, Tokunoshima, Okinoerabu, Okinawa, Miyako and Ishigaki. The frequency of the AHSG 5 allele in these areas was greater than 1% that can be called polymorphic frequency. The distribution of the AHSG 5 allele indicates that it is specific to the Nansei Islands.
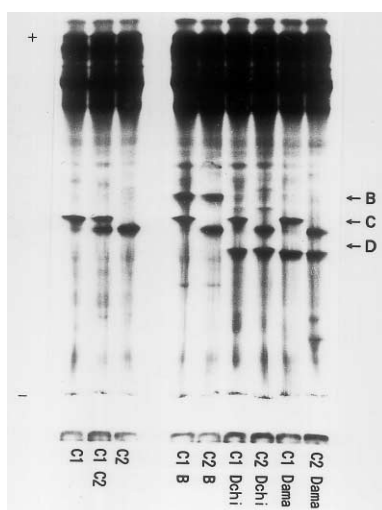
Fig. 2. Three common phenotypes controlled by TF C1 and TF C2 and rare variants by TF B and TF D alleles (Dchi: Dchina, Dama: Damami).

Conclusion

Our study of geographical clines of polymorphic alleles, and of rare alleles that are uniquely distributed within the Nansei Islands, suggests that the genetic makeup of people from this area can help us to understand the origin of the modern Japanese people. Additional data should provide greater insight in the future.

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A DATABASE OF THE PEST INSECTS FOUND ON ISOLATED ISLANDS IN KAGOSHIMA PREFECTURE, JAPAN

Yositaka Sakamaki

Abstract

A pest insect database for isolated islands in Kagoshima Prefecture was developed and made available for public use via the World Wide Web. Most of the insect fauna in this island area is unique and differs from that of central Japan. However, there are few publications with sufficient photographs or biological notes on agricultural pest insects living on such islands. By browsing the database, farmers and non-experts with little knowledge of pest insects can easily search for and identify a pest and get information on the method to control it.

Key words: Pest insect, Database, Isolated islands, Kagoshima, World Wide Web

Introduction

The isolated islands in Kagoshima and Okinawa prefectures, which are located at the southwestern end of Japan, have a subtropical climate. Many tropical crops and fruits that are not grown on the mainland are cultivated on these isolated islands, which are a poorly defended "gateway" to southwestern Japan for pest insects invading from Southeast Asia. The islands are also a source of tropical crops and fruits. Invading pests may find suitable host plants and successfully colonize such islands. To protect plants in Japan, it is important to enumerate the pest insect fauna on these islands, because we need to identify which species might extend their distributions. In the last century, some notorious pest insects have invaded these islands from Southeast Asia, the Philippines, and Oceania, including the sweet potato weevil (*Cylas formicarius*), coconut weevil (*Rhynchophorus ferrugineus*), melon fly (*Dacus cucurbitae*), and sweet potato vine borer (*Omphisa anastomosalis*), and some crops have suffered severe damage in Kagoshima and Okinawa (SAKAE, 1988).

Moreover, many species of migratory pests swarm and invade Japan from the Philippines and southern China every year, including the rice leaf roller (*Cnaphalocrocis medinalis*), brown delphacid (*Nilaparvata lugens*), and army worm (*Spodoptera litura*) (KIRITANI, 2001). They attack many crops in summer and autumn, but are unable to overwinter in Japan. However, greenhouses and the heat island phenomena will help them to colonize and overwinter in Japan.

Every year, a few new pest species are discovered in Japan, and these are reported in special reports from the plant protection office in some prefectures. New crops are introduced to Kagoshima and Okinawa prefectures from tropical areas every year. With the rapid proliferation of information on insect fauna and the introduction of new crops from tropical areas, farmers and pest management experts find it increasingly difficult to identify a pest insect using only printed publications. This paper presents a database system that focuses initially on pest insects distributed in mainland Kagoshima Prefecture and on the islands of Tanegashima, Yakushima, Amami-Oshima, Tokunoshima, and Okinawa. The database includes photographs of pest insects that attack crops, which should aid in pest identification.

Yositaka SAKAMAKI

The Database

Data were extracted from the literature, primarily from a Japanese atlas and papers published in Japanese journals. Minor data sources included research bulletins and reports from agricultural experiment stations. I took most of the photographs. Each database record consists of 13 fields (Table 1) and includes the scientific and Japanese common names of the pest, the names of the host plant(s), distribution on and off the islands, literature references, photographs of the pest, and control methods.

Table 1. Description of the fields contained in the database.

Field	Content of the field
1.	Taxonomic order of pest insect
2.	Taxonomic family of pest insect
3.	Scientific name of pest insect
4.	Author name describing the pest insect
5.	Japanese common name of pest insect
6.	Scientific name of host plant (crop)
7.	Japanese common name of host plant (crop)
8.	Distribution of isolated islands in Kagoshima Pref. and Okinawa
9.	Primary literature on pest damage and distribution
10.	Secondary literature
11.	Taxonomic and ecological notes
12.	Photograph
13.	Methods for controlling the pest

The database was developed using the commercial database program FileMaker Pro. 5.0. Currently, the database holds about 1,000 records, with photographs of over 50 important pests. Most of the pests are lepidopteran insects (over 900 species). The records can be searched either by inputting key words or by choosing key words from pop-up menus.

Even a beginner with no knowledge of pest insects can find a pest insect by searching for pest information in the database using key words. The database has been designed to fit the needs of farmers, and focuses on pest insects that are distributed on islands in Kagoshima and Okinawa prefectures. There are many publications on pest insects in central Japan; however, few of the insects described in such publications are distributed on isolated islands. There are few publications with sufficient photographs and biological notes on common agricultural pest insects living on islands. Unfortunately, the database does not yet contain sufficient good photographs of living pests attacking crops, but the number of photographs will be increased to facilitate effective use of the database by farmers and non-experts.

Browsing the Database on the WWW

The Japanese version of the database is available on the World Wide Web. Anybody can access it and browse the records. The database is stored on a server at the Kagoshima University Research Center for the Pacific Islands, and is linked to its homepage (http://cpi.kagoshima-u.ac.jp/index.html).

The main menu of the database offers the user five search methods: a key word search (input words) or pop-up menus for searches by the taxonomic order of the pest insect, taxonomic

Fig. 1. Top page exhibeted on WWW.

　　　　Top page gives search menu. Key words can be inputed in top two blank, and some
　　key words can be selected lower four pop-up menu. In this example host plant name
　"Satsumayimo (　　　　　)" is inputted as a key word.

Fig. 2. A list of search result.

　　　　The taxonomic order name, Japanese common name of each pest insect and that of
　　host plants are shown. Button combined square and circle in a left end of each record
　　is linked to detailed information page of each species.

family Japanese common name, and host name (Fig. 1). If any of the last four search methods are selected, all the user need do is choose an item on a menu. If the key word search is selected, the user can search records by inputting information, such as island name, insect name, host name, and so on. For example, if a user inputs the word" ", which is the Japanese word for sweet potato, the database exhibits a list of 14 records associated with sweet potato (Fig. 2). The list includes four fields (family name, Japanese common name, scientific name, and host plant in Japan) and one button per record. Each button is linked to detailed information on each species, including photographs. The original database file developed with FileMaker Pro can be manipulated in a manner similar to WWW browsing.

At present, 90% of the records in the database are for lepidopteran insects. More records for insects in other orders will be added in the near future, and an English version of the database will also be added. I plan to extend the database to include islands in neighboring prefectures and surrounding countries in the future.

Finally, I wish to sincerely thank Dr. K. TSUDA for critically reading this manuscript.

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INTERTIDAL MOLLUSCAN FAUNA IN MAGESHIMA ISLAND

Tomoko Yamamoto and So Ishida

Abstract

Molluscan fauna of intertidal rocky shores were investigated at Mageshima Island, which is located 12 km west of Tanegashima Island, Kagoshima Prefecture, Japan. Eighty-four species belonging to 31 families were sampled and they included many subtropical species. Some characteristics of this fauna showed that intertidal rocky shores of Mageshima Island were environmentally comparable to cobble shores.

Keywords: Fauna, Intertidal, Mollusca

Introduction

Mageshima Island is located 12 km west of Tanegashima Island and has a 12 km coastline and is 8.5 ㎢ in surface-area. It is a flat island with a maximum elevation of 71 m. Historically, this island had no residents and was used as a base for fishing or as a farm except from 1951 to 1980, when more than 500 people reclaimed the island and resided to cultivate sugarcane. The coast of the island is known for a good abalone fishery. Therefore, we can expect that this island has a preferable environment for coastal organisms because of very low human impact on intertidal shores and having subtidal shores which can persevere rich abalone resources.

There have been some studies dealing with terrestrial flora and fauna of Mageshima Island (SASAKI et al., 1960; NAKAMINE, 1976). One subspecies of sika deer, *Cervus nippon mageshimae*, was described from this island (KURODA & OKADA, 1950). Flora and fauna were also studied along the coast of the island (ARAKAWA, 1955; TANAKA, 1976; ITONO, 1979), and it has been known to have various algal species including some tropical species (TANAKA, 1950). However, coastal fauna and flora were rarely studied after residents abandoned the island.

In this study, we investigated intertidal molluscan fauna on some rocky shores of this island to gain some insight about the coastal fauna and their environmental condition.

Methods

Preliminary surveys were carried out on September 1998 at five shores of Mageshima Island. One person surveyed rocks in the intertidal area for 30 to 60 minutes at each shore during low tide and noted species name.

We selected two shores located on the east and west coast of the island based on data from the preliminary survey areas and surveyed again on August 2000. Cross-shore transects were set from the upper to lower reaches of the intertidal zone. All molluscan species along these lines were sampled and fixed in 10% seawater formalin.

Table 1. List of molluscan species in intertidal rocky shores of Mageshima Island.

Family	Species	Family	Species
Ischnochitonidae	*Ischnochiton comptus*	Muricidae	*Muricodrupa fusca*
Chitonidae	*Acanthopleura gemmata*		*Muricodrupa sp.*
	Acanthopleura loochooana		*Morula granulata*
	Acanthopleura japonica		*Morula musiva*
	Onithochiton hirasei		*Morula nodicostata*
Acanthochitonidae	*Acanthochiton rubrolineatus*		*Morula anaxeres*
Patellidae	*Scutellastraflexuosa*		*Drupa ricinus ricinus*
Nacellidae	*Cellana treuma*		*Thais savignyi*
	Cellana grata		*Thais clavigera*
Fissurellidae	*Emarginula variegata*		*Purpura panama*
	Motfortula picta	Coralliophilidae	*Coralliophila clathrata*
	Diodra quadriradiatus	Columbellidae	*Euplica varians*
Lottidae	*Patelloida saccharina*	Buccinidae	*Japeuthria ferrea*
	Patelloida pygmaea	Mitridae	*Strigatella scutula*
	Collisella heroldi		*Strigatella retusa*
	Nipponacmea schrenckii		*Strigatella zebra*
	Nipponacmea fuscoviridis		*Strigatella paupercula*
	Nipponacmea concinna		*Strigatella litterata*
	Nipponacmea radula	Costellariidae	*Pusia dichroa*
	Nipponacmaea nigrans	Conidae	*Conus ebraeus*
Trochidae	*Chlorostoma xanthostigma*		*Conus chaldaeus*
	Monodonta labio		*Conus coronatus*
	Monodonta perplkexa		*Conus boeticus*
	Cantharidus callichroa		*Conus flavidus*
Neritidae	*Nerita helicinoides*		*Conus sp.*
	Nerita helicinoides tristis	Arcidae	*Barbatia lima*
	Nerita striata		*Barbatia virescens*
	Nerita plicata		*Barbatia fusca*
	Nerita insculpta	Mytilidae	*Mytilus coruscus*
	Nerita albicilla		*Septifer bilocularis*
Litiopidae	*Alaba picta*		*Septifer virgatus*
Littorinidae	*Littoraria intermedia*		*Modiolus nipponicus*
	Littoraria articulata	Pteriidae	*Pinctada maculata*
	Nodililittorina radiata		*Pinctada martensii*
	Nodilittorina trochoides	Isognomonidae	*Isognomon acutirostris*
	Nodilittorina vidua		*Isognomon perna*
Rissoidae	*Zebina affinis*		*Isognomon sp.*
Cypraeidae	*Cypraea annulus*	Pinnidae	*Pinna muricata*
Ranellidae	*Cymatium tenuiliratum*	Ostreidae	*Saccostrea mordax*
Epitoniidae	*Gyroscala lamellosa*	Carditidae	*Cardita variegata*
Eulimidae	*Eulima sp.*	Veneridae	*Periglypta reticulata*
Muricidae	*Cronia margariticola*		*Gafrarium dispar*

Result and Discussion

A total of 84 species belonging to 31 families were sampled during this survey (Table 1). This number is almost equivalent to the total number of species in nine coasts of the Satsuma Peninsula (YANO, 2001). Since the latter study dealt with an area more than ten times as larger than this study, we can say that Mageshima Island has a more diversified intertidal molluscan fauna than that of the Satsuma Peninsula. Intertidal molluscan fauna in Mageshima Island was also more diversified than that of Chiringashima Island at the mouth of Kagoshima Bay, which is an uninhabited island. The latter has 57 molluscan species including 42 gastropoda.

Among 84 molluscan species in Mageshima Island, 61 were gastropoda, while only 17 species of bivalves were sampled. Since most rocky shores of Mageshima Island also had cobble stones, we sampled few settlement species including many intertidal bivalves. Among 61 gastropod species, at least 26 were carnivorous including many subtropical species belonging to Muricidae and Conidae. The ratio of carnivorous species to all gastropod species in Mageshima Island (26 to 61) was almost equivalent to that of the intertidal cobble shores found in Sakurajima Island (7 to 23) (INADOME, 2002). Since a large ratio of carnivorous species are characteristic to molluscan fauna in cobble shores, it can be said that the environmental conditions of intertidal rocky shore in Mageshima Island were intermediate between that of a rocky shore and a cobble shore.

Three species of gastropoda (*Acanthopleura gemmata, Nerita helicinoides tristis* and *Pusia dichroa*) are reported to be distributed only south of Amami Island. Some other species, e.g., *Nerita plicata* have their northernmost limit of distribution at Tanegashima Island. These species were also sampled from the southern part of the Satsuma Peninsula and thought to be an irregular distribution without any reproductive capacity. In Mageshima Island, they have enough density to have reproductive capacity and to be able to conserve their population.

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鹿児島県トカラ列島における在来家畜の意義：
口之島野生化牛保護のための生息調査

要　　旨

Haemaphysalis
flava　*Haemaphysalis*
longicornis

キーワード：

SIGNIFICANCE OF INDIGENOUS DOMESTIC OR FERAL ANIMALS IN THE TOKARA ISLANDS, KAGOSHIMA PREFECTURE - A SURVEY ON THE POPULATION OF KUCHINOSHIMA FERAL CATTLE AND THEIR HABITAT FOR CONSERVATION

Yoshitaka NAKANISHI, Daisuke FUJIHASHI
and Masaharu MANDA

Abstract

A survey was conducted to investigate the population and group size of Kuchinoshima feral cattle and their environment in 2001 from the viewpoint of the conservation of rare and endangered animal genetic resources. A total of 32 cattle including adults, the young and suckling calves were found in the southeastern area of the island between August and November, 2001. There were 13 cattle with 4 types of coat color, i.e. black, black and white, brown, and brown and white in August, whereas there was no brown animals in November. The cattle formed 5 groups at least comprising 3-12 individuals. All the ticks collected by dragging a flannel cloth (0.7×1 m) on the pasture were identified as unfed larvae of *Haemaphysalis flava* in August, while *Haemaphysalis flava* and *Haemaphysalis longicornis* were almost equally found in November. In addition, the

tick population in August was larger than that in November. Two watering places besides the one at Seramma hot spring were found in the habitat.

In conclusion, the number of Kuchinoshima feral cattle has been decreased since 1999, which may be influenced by a scarcity of watering places, a decrease in the amount of herbage available caused by extension of a paved road and/or infection of external and internal parasites.

Key words: Animal genetic resources, Habitat, Indigenous domestic animals, Kuchinoshima feral cattle, Ticks

緒　言

ha

材料および方法

１．調査期間

：　　　：　　　　　：　　　：

２．調査地の概況

．km　　　　．km

ha

位置図

1:25,000

3．調査方法

．×．

t

結果および考察

1)2001 年 8 月 16〜17 日

| | 成長区分 | | | | | | | | | | | | |
| 毛色 | 成牛 | | | | 育成牛 | | | | 哺乳子牛 | | | | 計 |
	雄	雌	不明	小計	雄	雌	不明	小計	雄	雌	不明	小計	
黒 毛		4		4	1			1		2		2	7
黒 毛 白 斑	2			2						1		1	3
褐 毛		1		1									1
褐 毛 白 斑		2		2									2
小 計	2	7		9	1			1		3		3	13

2)2001 年 11 月 3〜7 日

| | 成長区分 | | | | | | | | | | | | |
| 毛色 | 成牛 | | | | 育成牛 | | | | 哺乳子牛 | | | | 計 |
	雄	雌	不明	小計	雄	雌	不明	小計	雄	雌	不明	小計	
黒 毛	4	10	2	16	1			1		1		1	18
黒 毛 白 斑	2	2		4						1		1	5
褐 毛													
褐 毛 白 斑		1		1									1
小 計	6	13	2	21	1			1		2		2	24
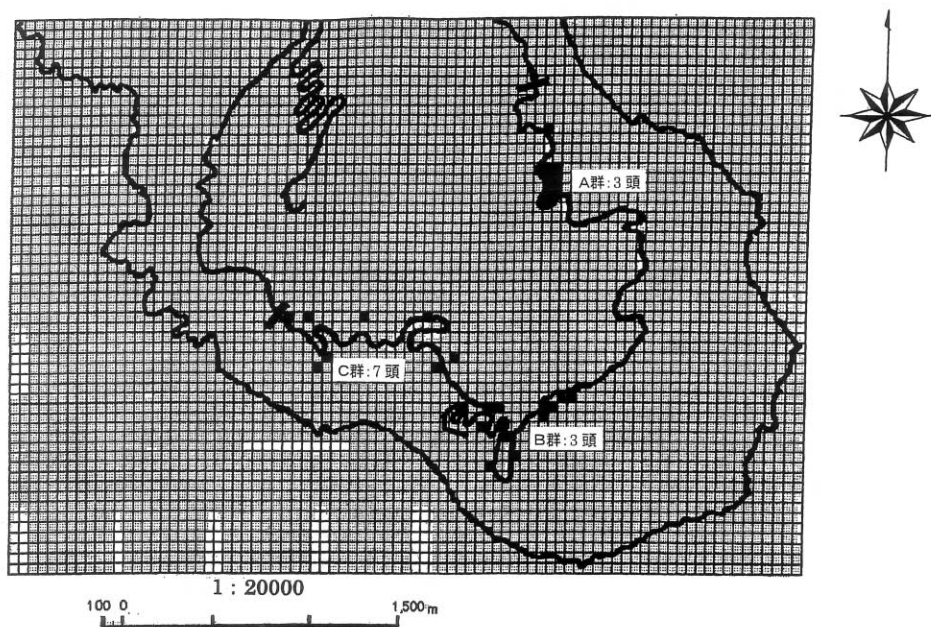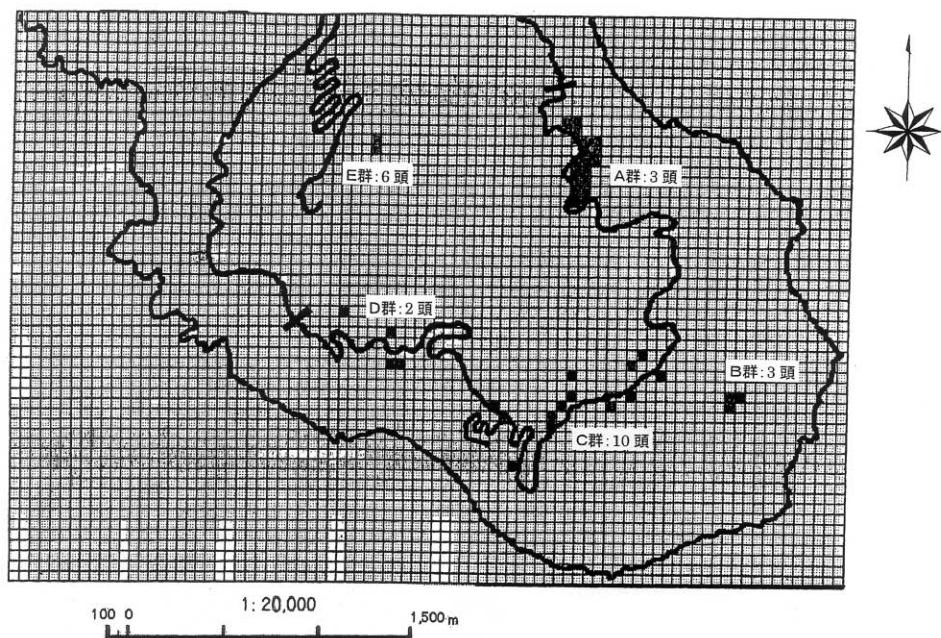
上図

A群：3頭

C群：7頭

B群：3頭

1：20000

100　0　　　　　　　　　　　　1,500 m

下図

E群：6頭

A群：3頭

D群：2頭

B群：3頭

C群：10頭

1：20,000

100　0　　　　　　　　　　　　1,500 m

地 域 名	調 査 時 期	
	2001 年 8 月 17 日	2001 年 11 月 5 日
	－個体／10a－	
アカズラ	── **	9,960
三千木	13,867[a]	1,900[b]
メイケンタオ	4,467	2,180
セランマ(1)	8,667	1,300
セランマ(2)	7,767[c]	1,980[d]

* . × . m　　　　　　　　　　　　m

**

ₐ,ᵦ P＜ .　　ᵪ,ᵈ P＜ .　　　　　　　*t*

Haemaphysalis flava

Haemaphysalis longicornis

謝　辞

文　献

NECROSIS AND REGENERATION OF THE SKELETAL MUSCLE WITHOUT A MARKED HEMORRHAGE INDUCED IN THE RAT BY ENVENOMATION OF *TRIMERESURUS FLAVOVIRIDIS* VENOM AND ITS COMPONENTS, PHOSPHOLIPASE A$_2$ ISOZYMES

Motoo KITANO, Masato HIRANO, Takashi ISHIHARA, Taketomo HASHIMA, Eri UMEMURA, Aichi YOSHIDA, Shosaku HATTORI, Naoko UEDA, Motonori OHNO

Abstract

A histopathological study of the lesions caused by sublethal doses of *Trimeresurus flavoviridis* (*Tf*) venom injected into the anterior thigh muscle (quadriceps femoris muscle; QFM) of rats was done. A dose of 50µg of *Tf* venom (crude venom, and three kinds of the phospholipase A$_2$ isozymes of *Tf* venom; [Asp^{49}]PLA$_2$, BPI and BPII) produced a large area of necrosis in QFM. Myonecrosis was evident 30 minutes after the injection, and over the following 72 hours the necrotic muscles remained acellular and devoid of inflammatory reaction except at the very edge where liquefaction necrosis associated with inflammatory infiltrate was marked from the beginning. Blood vessels in and around the necrotic foci were often involved in inflammatory changes and thrombosis, to some degree. However, marked hemorrhage was never noted. Phagocytosis of debris proceeded from the periphery, and after 24 hours the muscle was replaced by granulaion tissue containing many regenerating myoblastic cells. Interestingly, the myonecrogenic *Tf* venom itself may cause marked and extensive activation of muscle fiber regeneration, and the venom seems to be a great myotoxin but not a hemorrhagenic toxin for the rat.

Key words: *Trimeresurus flavoviridis*(*Tf*), Envenomation, Myotoxin, Skeletal muscle, Quadriceps femoris muscle (QFM), Myonecrosis, Regeneration, Myoblast, PhospholipasesA$_2$ isozymes, Hemorrhage

Introduction

Envenomation of *Trimeresurus flavoviridis* (*Tf*) snake venom causes two main symptoms, one local and the other systemic in humans. The local symptoms are severe pain, swelling, hemorrhage and necrosis in compliance with the bitten extremity, result in permanent disability or amputation (HOMMA and TU, 1971). In the Amami islands of Kagoshima Prefecture, this accident accounts for about 90% of snake bites. Subsequently, experimental pathological studies with the venoms of the snake have centered on local muscle necrosis and on local hemorrhage (HOMMA and TU, 1971).

We have examined the short term effects of the various components of *Tf* venom on rat skeletal muscle, quadriceps femoris muscle (QFM), with closer attention to impairment, necrosis and regeneration of muscle fibers, the latter occurring even at the earlier stages. Moreover, the rats have shown a strong resistance to hemorrhage by envenomation of *Tf* venom. Renewed interest in this venom has stemmed from our recent studies of its action on muscle and vascular wall of the rat and from its fractionation of the venom, which may shed light on the pathogenesis of local

lesions caused by the snake bites.

This article is written based upon an oral presentation to Symposium I ' *Habu* (*Trimeresurus flavoviridis*) in Amami Islands' at the 26th Kyushu Regional Meeting of the Japanese Society of Tropical Medicine, held on January 26, 2002, in Kagoshima. Interested readers may refer to the original publication for detailed data (KITANO et al., 2001).

Materials and Methods

Venom and its phospholipase A2 isozymes

Tf venom was collected in Amami-Oshima island and lyophilized. Its phospholipase A_2 (PLA_2) isozymes, [Asp^{49}]PLA_2, BPI and BPII, the latter two being [Lys^{49}]PLA_2s, were separated by conventional chromatographies at Sojo University (LIU et al., 1990; KIHARA et al., 1992). The crude venom and PLA_2 isozymes were weighed and dissolved in sterile physiological saline just before use.

Experimental design

Young adult female and male rats of F344, Dark-Agouti, Wistar/Furth strains were divided into two to five groups, each group consisting of 6 rats (total; 90) (Table 1).

The rats were anesthetized with pentobarbital sodium (Nembutal). The crude venom and three PLA_2 isozymes (50μg each) in 100μl physiological saline were injected into each rat of four groups at the upper two-thirds of the right QFM. The fifth group, the control rats, were similarly injected with 100μl of only physiological saline.

The animals were allowed to survive for the periods ranging from 30 minutes to 72 hours and were sacrificed under ethyl ether anesthesia. Both the right and left hindlimbs, the visceral organs and brain were immersed for several days in 10% buffered formalin (pH 7.4), and processed for paraffinic embedding. The sections of 5-6μm thickness were stained with hematoxylin and eosin for histopathological examination.

Histopathoμlogical Findings

The muscle tissue injected with only physiologic saline had a typical histology of skeletal muscle with no abnormality in muscle fibers, nerves or blood vesseles.

In the rats inoculated with toxins, no significant differences were detected among the four kinds of toxins, among three strains of rats and among female and male rats, so we preferred to describe here all together.

There was a more or less marked sign of liquefaction necrosis with a depressive or atrophic features of the muscle masses of QFM in the venom-injected right hind leg. A close examination of the injected QFM revealed an absence of marked hemorrhage except for a few rats (Fig. 1).

As early as 30 minutes after the inoculation of *Tf*-venom, there were groups of affected cells accompanied by the decrease of fine cytoplasmic structures to some degree, which were located in the periphery of the muscle. At this time edema without inflammatory cells were observed, and many of the skeletal muscle cells presented edematous swelling.

Six hours after injection, the necrosis of muscle fibers in QFM was indicated by nuclear pyknosis and fragmentation of the myofibrils into homogenous eosinophilic masses separated by empty-looking segments. The earliest alterations seem to take place in the periphery of the necrotic focus where a very mild inflammatory infiltrate was observed at this time.

After the elapse of 24~48 hours there was widespread myonecrosis (Fig. 2); the myofibrillar

Table 1. Experimental rats with snake venom injection into the QFM.

Venom of snake (Tf)	Durat-ion	N of rat*	Skeletal muscle fibers and endomysium					Perimysium, epimysium and surrounding connective layers				
			Necrosis	Inflam-matory infiltr-ation	Hemo-rrhage	Edema	Musc-ular re-generat-ion	Inflam-matory infiltr-ation	Changes in the vascular walls**	Hemo-rrhage	Edema	Others#
Crude venom	30m	6	-	-	-~+	+	-	-	-	-	+	-
	6h	6	-~+	+	-~+	+	-	-~+	-	-	+	-
	24h	6	++~+++	+++	-~+	++	+	++	-~+ (Th)	-~+	++	-
	48h	6	++~+++	+++	-~+	++	++	++	-~+ (Th)	-~+	++	+
	72h	6	++~+++	++	-~+	++	++	++	-~+ (Th)	-~+	++	+
	Total	30										
[Asp49] PLA$_2$	24h	6	++	++	-~+	++	+	++	-~+ (Th)	-	++	-
	48h	6	++	++	-~+	++	+	++	-	-	++	-
	Total	12										
BPI	24h	6	++	+~++	-~+	++	+	+	-~+ (Th)	-	++	-
	48h	6	++	+~++	-~+	+	++	+	-~+	-	+	-
	Total	12										
BPII	24h	6	++	+~++	-~+	+	++	+	-~+	-	++	-
	48h	6	++	+~++	-~+	+	+++	+	+	-	++	-
	72h	6	+	+	-~+	+	+++	+	-	-	++	-
	Total	18										
Control (physio-logical saline)	30m	6	-	-	-	-	-	-	-	-	-	-
	24h	6	-	-	-	-	-	-	-	-	-	-
	48h	6	-	-	-	-	-	-	-	-	-	-
	Total	18										
Rat, total N		90										

*One group consists of male and female rats of three strains (F344, Dark-Agouti, Wistar/Furth). However, there is neither strain nor sex differences in the essential histopathological changes among nenom kinds and duration.

**Inflammatory changes are noted in the medium-sized vascular walls. Th means' thrombosis' .

Necrotic changes are noted in the fatty tissue around the fascia.

material in necrotic cells was more amorphous and its distribution within the cellular space was more homogeneous, instead of being dense and clumped masses (Fig. 3). A marked and dense inflammatory infiltrate was present outside the necrotic cell nests. There was little hemorrhage at this or later times, although edema was considerably marked. Simultaneously, regenerative proliferation of myoblasts. The regenerating cells were spindle in shape with scanty basophilic cytoplasm and a central nucleus, some revealing mitotic activities at 48 hours (Fig. 4). Muscle regeneration was observed in the peripheral fibers of necrotic muscles, but the inner parts of those muscles appeared still necrotic. The regenerating cells gradually became hypertrophic with an acidophilic light cytoplasm at 72 hours. The muscle tissue examined histologically 8 weeks after the onset of muscle necrosis was characterized by the presence of abundant regenerated muscle cells with centrally-located nuclei and a diameter similar to that of normal muscle cells, indicating that regeneration took place successfully (data, not shown).

There was little hemorrhage through the whole duration. Most blood vessels looked normal, but in some animals inflammatory infiltrate was noted in the vascular walls and platelet thrombi were found in some medium-sized veins and arteries, occasionally forming occlusive masses. There were several peripheral nerves showing marked edema of the endoneurium, but no apparent structural disintegration was found.
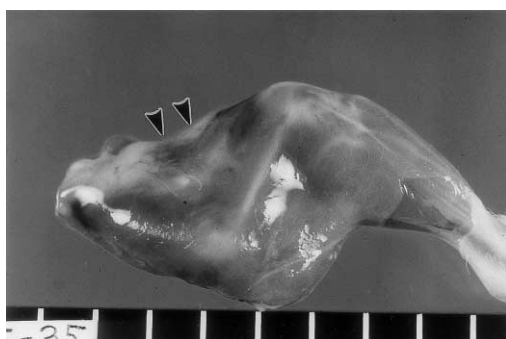

Fig.1. A large necrotic lesion in the QFM of a F344 male rat 48 hours after the inoculation of the crude venom of *Tf*. Note the severe and extensive atrophy of the skeletal muscles of the anterior thigh due to liquefaction necrosis (arrow heads). Slight focal hemorrhage is noted in the necrotic area.
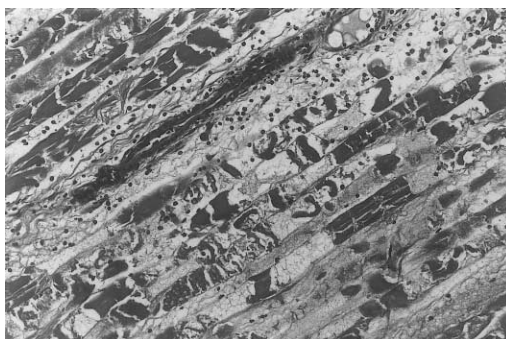

Fig.2. Massive necrosis of the QFM of a F344 male rat 48 hours after the inoculation of the crude venom of *Tf*. Marked reactive changes (Re) are seen in the peripheral areas of the necrotic layer, most of which is composed of exudated inflammatory cells and regenerated myoblastic cells. There is no detectable hemorrhage in this case.
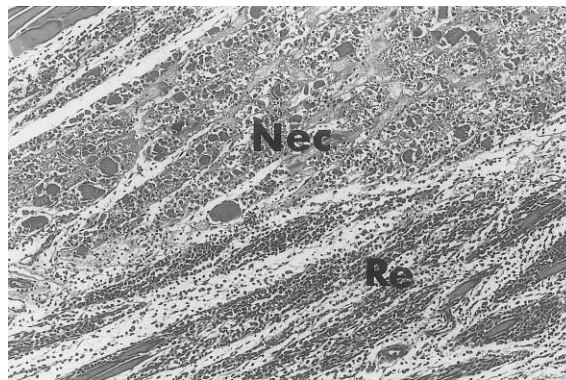
Fig.3. Massive and extensive liquefaction necrosis of the skeletal musle fibers of QFM of a F344 male rat 48 hours after the inoculation of the crude venom of *Tf*.
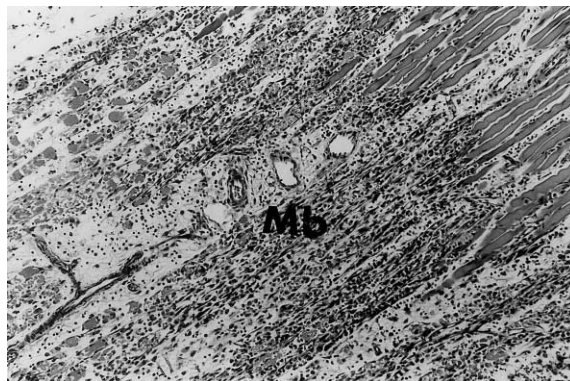

Fig.4. A reactive tissue in the periphery of a necrotic focus in a female F344 rat 48 hours after inoculation of the crude venom. Many myoblastic cells (Mb) are sprouted from the viable skeletal muscle fibers. Mitotic figures are noted in the regenerating cells, some of which have two nucleoli.

Discussion

Thirty minutes after the injection of *Tf* venom, initial changes of muscle fiber necrosis was widespread in QFM, where most blood vessels looked normal and contained no thrombi. These findings show that necrosis is an early event, which probably results from a direct action of the venom on the muscle fibers.

On the other hand, muscle necrosis by the local inoculation of various kinds of snake venoms is usually followed by the rapid phagocytosis of debris at the periphery of the necrotic area. The clearing of necrotic material by phagocytes was followed by a rapid regeneration process. Myoblasts were observed 24 hours after the onset of myonecrosis, and by 8 weeks regeneration was complete. The success of regeneration after myonecrosis induced by *Tf* myotoxin might be due to the fact that neither nerves nor blood vessels are markedly affected by this toxin, since adequate blood supply and innervaton are essentially requirements for the muscle regeneration (QUEIROZ et al., 1984; GUITIERREZ et al., 1989).

The most striking effects produced by the injection of many snake venoms, including venom

of *Tf*, are local, consisting of marked hemorrhage, myonecrosis, and edema in animals (OHSAKA et al., 1960; OKONOGI et al., 1960; LOMONTE et al., 1994). It is well known that the pathological signs characteristic of *Tf* bite in humans, rabbits and mice are marked by extensive hemorrhage and necrosis (OKONOGI et al., 1960). Our experimented rats, however, failed to demonstrate that hemorrhage was a predominant sign of snake venom injection. We used three strains of rats and four kinds of preparations of *Tf* venom for our experiments. In spite of the difference of strains of rats and kinds of venom-preparations, we could not note marked hemorrhage in and around the injection area, although a few rats showed focal slight hemorrhage in the necrotic areas.

It is of great interest whether or not the same principle is responsible for necrosis and hemorrhage. Many researchers stated that hemorrhage is due, at least in part, to the action of myonecrotic enzymes, such as phospholipase A_2 (LOMONTE et al., 1994). Concerning local hemorrhage, our results did not agree with the general view that snake venoms produce bleeding at the site of injection. Pathological observations indicated that the easily discernible local changes produced in the humans, rabbits and mice by *Tf* bite injury were hemorrhage. However, in the present experiment, *Tf* venom did not give rise to any prominent bleeding locally, but produced myolysis with edema, in the rats.

Some investigators have suggested that proteolytic enzymes are factors in hemorrhage and necrosis (OHSAKA et al., 1960; OKONOGI et al., 1960). Our observations concerning the degree of hemorrhage and necrosis were not always in parallel with proteolytic activities. Furthermore, there is a report that a crystalline trypsin produces local hemorrhage and almost no myonecrosis (HOMMA and TU, 1971). This seems to indicate that both changes depend not only on proteolytic enzymes, but also on other enzymes or factors.

A few reports have described the occurrence of vascular lesions in a poisonous snake bite (MANDELBAUM et al., 1989; MATSUI et al., 2000; ESTEVAO-COSTA et al., 2000). It was confirmed that the venoms containing both myonecrogenetic and hemorrhagic activities, *crotalinae* and *viperinae* venoms, inflicted damage on the arteries and that the venoms devoid of hemorrhagic activity, *elapidae* venoms, fail to cause significant changes in the arterial walls. The important changes responsible for developing arterial lesions appear to be the injury of the endothelium and the disintegration of the media. It has been reported that *Tf* venom attacks the endothelium and smooth muscles of the media when the venom is injected close to the arteries. This suggests that both hemorrhagic and myonecrogenetic factors play an important role in the involvement of local blood vessels (MATSUI et al., 2000).

In conclusion, the *Tf* venom seems to be a great myotoxin but not a hemorrhagenic toxin for the rat. Simultaneously the myonecrogenic *Tf* venom itself may cause marked and extensive activation of muscle fiber regeneration.

Acknowledgements

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