Research Institute for Humanity and Nature Research Project

A Study of Human Subsistence Ecosystems in Arab Societies:

To Combat Livelihood Degradation for the Post-oil Era (HSEAS)

A Study of Human Subsistence Ecosystems with Mangrove in Drylands: To Prevent a New Outbreak of Environmental Problems

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Research Institute for Humanity and Nature

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National Institutes for the Humanities
Research Institute for Humanity and Nature

Message from the Director-General

TACHIMOTO Narifumi

The Research Institute for Humanity and Nature (RIHN) was established to conduct comprehensive, integrated research (global environmental studies) in order to create an academic discipline directed to solution of the earth's environmental problems. As one of the National Institutes for the Humanities of the Inter-University Research Institute Corporation, RIHN is unique in promoting the fusion of sciences and the humanities.

Environmental problems are said to have reached global proportions as modern civilization challenged and sought to control nature. Such global environmental problems are rooted in human culture in the broadest sense of the term. With this basic understanding, we at RIHN consider that the solution of global environmental problems lies in unraveling the chains of interaction between man and nature and seeking new paradigms of dynamic equilibrium.

Research into the essence of global environmental problems is organized at RIHN through a system of research projects and fixed-term appointments. Supported by cooperative research with universities and research institutes at home and abroad, this system of fixed-term projects gives rise to the features of integration, international networking, leadership and fluidity that characterize our inter-university research institute. In particular, the selection of projects involves rigorous evaluation by a committee comprised entirely of external members including overseas researchers.

In March 2007 the initial projects were completed, and more projects will reach completion in the near future. In response to this, a system of programs that bring together several projects has been introduced into the Research Department, and the former Research Promotion Center has been restructured as the Center for Cooperation, Promotion and Communication (CCPC). This CCPC will function not only to support research but also to establish the core identity of RIHN and organize the dissemination of results. From this year, the projects are grouped in this prospectus according to the domain of the program to which they belong.

In this way, based on an organizational system of research that is unique not only in Japan but also worldwide, RIHN is poised to take flight as a research institute of which Japan can be proud, where researchers, educators and staff from a diversity of fields gather to face new challenges. I invite your warm understanding and support, together with your criticisms, of not only this prospectus but all of RIHN's activities.

Founding Mission and Goals

The Research Institute for Humanity and Nature (RIHN) was established in April 2001 as an inter-university research institute of the Ministry of Education, Culture, Sports, Science, and Technology. It was to conduct comprehensive research in order create an academic discipline directed to solution of the earth's environmental problems.

Environmental research has hitherto been tackled in various separate fields of the natural sciences. RIHN's mission is to clarify the essence of environmental problems and identify ways that man should interact with nature. It is necessary to understand that environmental problems have three dimensions or aspects.

The first dimension is that of environmental problems in daily life, including various problems related to the human body and people's lifestyles. The second is that of socially constituted problems. These include global warming, loss of biodiversity, depletion of water resources, pollution by waste, and salt-water damage. An important task here is to clarify the social (political and economic) systems that cause these problems. The third dimension is that of "true" environmental problems. These are problems related to the mechanisms of and changes in global systems, such as the atmosphere, water, land, and climate, which are primarily the concern of the natural sciences and earth sciences.

Global environmental studies is not a finished, systematized discipline but something to be built for man's future survival through continuing trial and error. In this regard, the aim should be to build a constantly changing dynamic system.

At RIHN, we firmly believe that environmental problems concern humanity and all living organisms that presently inhabit the earth or will do so in the future. The "comprehensive" research that is RIHN's mission means not only the integration of academic domains but also the pursuit of understanding a phenomenon in its entirety.

If global environmental problems are rooted in human culture, then the global environmental studies to which RIHN aspires can be regarded as humanics, the inquiry into how humans live. For this reason, global environmental studies should stand at the starting point of environmental studies, dealing with the problems of humans and humanity in the midst of nature.

Features of RIHN

Integration

Research aimed at solving global environmental problems has progressed in many fields worldwide in recent years. At RIHN, we focus on problems such as warming, rising sea levels and loss of diversity at a regional level and, because regional problems have a complex bearing on the earth as a whole, we consider it necessary to conduct the basic research of field survey and data accumulation within an integrated framework that includes correlations with human existence. Research into questions of human lifestyles and culture is naturally based on the methods and viewpoints of the humanities and social sciences; but in carrying out such research, we consider it important to combine this approach with the methods and viewpoints of the natural sciences. An interactive approach between the natural sciences and the humanities and social sciences leads to the integration of global environmental studies as humanics.

International Networking

Research projects at RIHN involve not only researchers from domestic universities and research institutes but also overseas researchers participating through agreements with research institutes overseas. RIHN also actively participates in the planning and operation of research projects at overseas institutes and invites overseas researchers to RIHN as visiting faculty or researchers. In 2006, 58 scholars from overseas took part in our first international symposium and four satellite symposia. In 2007, our second international symposium attracted 28 researchers from overseas. In 2008, overseas researchers will again be invited to our third international symposium.

Leadership

Research projects at RIHN are grouped under one of five programs according to the research domain, and each program has an overall leader. Through the program leaders and project leaders, research projects are implemented in an integrated fashion. The Director-General, Deputy Director-General, program leaders and head of the Center for Cooperation, Promotion and Communication play central roles at home and abroad in coordinating the building of global environmental studies, disseminating research results, organizing international symposia, and responding to internal and external evaluations.

Fluidity

At RIHN, all professors, associate professors and assistant professors participate in research projects on the basis of fixed-term appointments, and project researchers and others similarly finish their terms of appointment with the completion of the project. This project system ensures the fluidity of personnel. Projects, moreover, progress from incubation study (IS) through feasibility study (FS) and pre-research (PR) to full research (FR), and the project system allows a flexible response to the organizational and personnel requirements at each stage. Fluidity is also realized through the constant exchange of personnel with domestic partner institutes.

Towards Consilience and Futurable Societies

Research at RIHN seeks to elucidate the chains of interaction between man and nature. Research programs are established in five domains, circulation, diversity, resources, environmental history, and global area studies (ecosophy); and each program comprises a number of projects with a variety of topics, concerned with a diversity of areas and time-scales. In this situation, it is necessary to establish a clear direction in which unify these projects as constituents of global environmental studies.

Research projects at RIHN have hitherto been grouped under a diversity of topics, including water circulation, atmosphere, climate, oceans, underground environments, islands, ecosystems, food production systems, disease, landscapes, and civilizations. These individual studies have been classified along particular axes of research.

We consider it a major mission of RIHN to build consilience among these research axes within a more readily comprehensible framework of global environmental studies. Building consilience will elucidate the essence of global environmental problems and allow us to grasp them through new paradigms. This in turn will allow us to plan for the formation of futurable societies.

The new framework for research comprises five so-called domains (**Figure 1**). The domains of circulation, diversity, and resources provide frameworks for the analysis of problems related to the dynamics of man's interactions with nature. These three together encompass environmental studies of the humanosphere. Studies along the axes of time and space are respectively classified in the domains of environmental history and global area studies (ecosophy). Environmental history looks at the change and continuity in civilizations from past to present and explores possibilities for the future. Ecosophy can be called the study of governance in the widest sense, seeking to understand regional environmental problems in conjunction with global environmental problems. In this way, we consider global environmental studies to rest on three pillars: the domains related to man's interaction with nature (circulation, diversity, and resources), environmental history, and ecosophy.

The five programs, RIHN's mission and direction are shown on the following page in Figure 2.

Figure 1 Concept of Global Envilonmental Studies

Figure 2 Building Consilience

Circulation Domain Program Centered on the sphere of human survival, this program deals mainly with problems arising from excess and deficiency, imbalanced distribution and overuse in the circulations of water, atmosphere, carbon, nitrogen and other materials.

Diversity Domain Program This program addresses global environmental problems of recent concern arising mainly from the loss of diversity, whether biological, including genetic diversity and diversity of niches, or cultural, including diversity of languages, social structures, religions and world-views.

Resources Domain Program This program covers problems related to the food and energy that support human survival and their means of production through agriculture, forestry and fisheries; and problems related to the human body, including health and nutrition.

Environmental History Domain Program This program takes and interdisciplinary approach to the history of global environmental problems as the "chains of interaction between man and nature."

Global Area Studies (Ecosophy) Domain Program This new domain of scholarship is expected constitute a completely new framework for global area studies that lies beyond the bounds of existing academic fields.

RIHN Research Project

A Study of Human Subsistence Ecosystems in Arab Societies: To Combat Livelihood Degradation for the Post-oil Era

Project Leader: Hiroshi NAWATA (RIHN)
Research Period: 2008-2013
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This project aims to promote basic studies to clarify human life-support mechanisms and self-sufficient modes of production among Arab people who have survived the peculiar natural environment of drylands for more than one thousand years. Using the research results, we intend to propose a scientific framework to strengthen their subsistence productivity and combat livelihood degradation in local Arab communities in order to prepare for the post-oil era.

Research Areas

Objectives

Japan and oil-rich countries of the Middle East have put excessive pressure on the Earth's resources in terms of energy, water, and food. As they have prioritized economic prosperity for their own benefit, they have exploited irreplaceable resources, such as fossil fuel and fossil water. These practices have placed stress on local ecosystems with the planting of alien species, and furthered social differences among the people of the Middle East. As we are facing a turning point in our modern oil-based civilization, our inter-dependency, based on the trading of fossil fuel, must change drastically to a new form of inter-dependency, in order to build a viable society for the future.

We focused on human subsistence ecosystems, which are human life-support mechanisms and self-sufficient modes of production (hunting, gathering, fishing, herding, farming, and forestry) with low energy resource consumption. We also take another look at advanced technology and economic development, and re-examine the conceptual framework of comprehensive measures to combat desertification. Based on these research results, we intend to propose a scientific framework that would strengthen subsistence productivity and rehabilitate the daily life of the general population in Arab societies for the post-oil era.

Research Methods and Areas

A study of human subsistence ecosystems in Arab societies will be developed and implemented in three separate areas: 1) comprehensive measures to control the alien invasive species mesquite; 2) an assessment of the environmental effects of development programs in coastal zones of the arid tropics; and 3) supporting peoples' decision-making by sharing research results.

Our research consists of two main approaches: (1) an analysis of subsistence ecosystems focusing on keystone species (camels, date-palm, mangrove, and coral (reef)); and (2) an inspection of the sustainability and fragility of Arab societies focusing on ecotones (wadi beds, riverbanks, mountain side, and sea shore).

Field surveys will be conducted in semi-arid lands between the River Nile and the Red Sea in Sudan, with the Red Sea coast, Butana area, and River Nile area as the main survey areas. Additional sub-survey areas will be the Sinai Peninsula in Egypt, Red Sea coast in Saudi Arabia, and a Sahara oasis in Algeria. We will compare keystone species, ecotones, and traditional knowledge and examine differences in the sustainability of a subsistence economy under site-specific conditions.

Expected Results

We will make the research results available for decision-making by local people and to those making national policy by providing data in Japanese (as a bridge between Japanese and Arab societies), English (the scientific language), and Arabic (the local common language).

Initially, we will hold an international symposium "Human subsistence ecosystems with mangrove and coral reef in drylands" to compile knowledge from various areas of science and from researchers with different backgrounds on this particular topic as the starting point of the project. Then, we will publish the results of this symposium in English and Arabic to distribute to local people in Arab societies. By obtaining their comments through interviews and questionnaires, we plan to feed their opinions back to our project targets and research activities, and hope to publish a revised version of the book, the product of information sharing, when we have finished the project.

Assessment of the environmental effects of development programs in coastal zones of the arid tropics

The coastal zones, where fresh water can be obtained from seawater, have become a development frontier, and this may cause environmental degradation by releasing highly concentrated saline water into the sea. In addition, this area is rich in biodiversity, so it has great potential for seafood and pastoral food production through mangrove reforestation as fish nurseries and safe foraging sites. We are compiling scientific knowledge to prevent a new outbreak of environmental problems with further coastal development.

Study and Activities on Mangrove Afforestation in Arabia

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Key words: afforestation, Al Gurm Research Centre, arid area, *Avicennia marina*, mangrove, plantation, restoration.

Research Area:

Kuwait, Bahrain, Qatar, United Arab Emirates, Saudi Arabia, Pakistan, Iran, Oman, Yemen, (Djibouti, India, Philippine, Thailand, Taiwan, Hong Kong, Bangladesh, Myanmar, Eritrea, U.S.A., Ecuador, Viet Nam)

Why did we attempt mangrove afforestation in Arabia?

Our final target was to restore the mangrove forests that had deteriorated or disappeared on the coasts of Arabia. The Al Gurm Research Centre initiated this program in early 1978.

The Arabian Peninsula is one of the most arid areas in the world. However, given their physiological diversity, some species of mangrove tree have found their niche along the Arabian coast. Unfortunately, these mangrove forests are declining or have disappeared as a result of activities such as over-cutting, over-grazing or modern development. Climatic desiccation is also a concern. Our explorations confirmed the ecological and economic importance of mangrove forests for the local people. The effectiveness of mangrove restoration and afforestation has also been realized through our experiences.

1) The use of mangrove trees as firewood and as building material for houses and boats was once very important. However, this changed when oil came under the management of the nation.
2) The leaves of *Avicennia marina* are used as fodder for camels. This is still one of the main uses of this species by local and nomad people in Arabia as well as in other arid or semi-arid areas from India to Africa.
3) The local people recognize the importance of mangrove forests for the environment. Fishermen know the locations of remote mangrove forests because they provide valuable resources such as shrimp.

In terms of mangrove afforestation, our main obstacle was lack of knowledge and technique. We knew little about the wild vegetation of mangrove forests. In addition, few people recognized the importance of mangrove afforestation, which seemed to have little economic value. However, years of trial and error with experimental plantations at various locations as well as observations in the field have provided us with a basic understanding of mangrove reforestation and restoration. This knowledge base has been created and developed with the help of the continued support of a variety of individuals and organizations.

Grazing camels in an *Avicennia* forest on Farasan Kabir

Rhizophora forests in the Red Sea provide migratory birds good nesting sites

Activities on Mangroves in the Middle East (and some other areas) made by Al Gurm Research Centre/ ACTMANG (Action for Mangrove Reforestation), 1978 - present

[1978]

- Establishment of "Al Grum Research Centre"
- Feasibility study for mangrove cultivation in Kuwait

[1979]

- Experimental plantation of mangroves in Kuwait
- First mangrove research to the Middle East (Kuwait, Bahrain, Qatar and United Arab Emirates), supported by Japan Cooperation Center for the Middle East

[1981]

- Experimental plantation of mangroves in Ras al Khafji, Saudi Arabia, supported by Arabian Oil Company (to be continued until 1990)
- Ecological research of mangroves in Pakistan, India, Yemen, Djibouti and United Arab Emirates
- Second mangrove research to the Middle East (United Arab Emirates, Kuwait, Saudi Arabia, India and Pakistan), supported by Japan Cooperation Center for the Middle East

[1982]

- Ecological research of mangroves in Philippine, Thailand, India, Pakistan, Bahrain and Oman
- Third mangrove research of mangroves to the Middle East (United Arab Emirates, Iran, Pakistan and India) supported by Japan Cooperation Center for the Middle East

[1983]

- Experimental plantation of mangroves in Mubarras Is., Abu Dhabi, supported by Abu Dhabi Oil Company (to be continued until 1985)
- Ecological research in Philippine, Thailand, India, Pakistan, Bahrain, Oman and Red Sea coasts of Saudi Arabia

[1984]

- Ecological research of mangroves in Taiwan, Hong Kong, Oman and Red Sea coasts of Saudi Arabia

[1985]

- Ecological research of mangroves in Bahrain, Oman, United Arab Emirates and Oman
- Feasibility study for rehabilitation of mangrove forests in Truk Islands, supported by UNDP/UNESCO
- Feasibility study for reforestation of mangroves in Pakistan, supported by UNDP/UNESCO

[1986]

- Fourth mangrove research to the Middle East (Oman), supported by Japan Cooperation Center for the Middle East
- Second feasibility study for reforestation of mangroves in Pakistan, supported by UNDP/UNESCO
- Advising mangrove planting technology to Qatar government
- Third feasibility study for reforestation of mangroves in Pakistan, supported by UNDP/UNESCO
- Feasibility study for reforestation of mangroves in India, supported by UNDP/UNESCO
- Feasibility study for rehabilitation of mangroves in Bangladesh, supported by UNDP/UNESCO

[1987]

- Ecological research of mangroves in Oman

[1988]

- Ecological research of mangroves in Qatar and Abu Dhabi
- Technical assistance to the government of Qatar for mangrove restoration/afforestation through Japan International Cooperation Agency (JICA) scheme (to be continued until 1996)

[1989]

- Ecological research of mangroves in Qatar, Abu Dhabi and Red Sea coast of Saudi Arabia

[1990]

- Feasibility study for mangrove restoration in Myanmar, supported by UNDP

[1991]

- Feasibility study and experimental plantation of mangroves in Myanmar, supported by UNDP/FAO (to be continued until 1993)

[1992]

- Establishment of Action for Mangrove Reforestation (ACTMANG)
- Feasibility study on mangrove plantation in Eritrea, cooperated with "Manzanar project" (USA)
- Mangrove research for conservation and reforestation in USA and Ecuador, supported by Japan Overseas Forestry Cooperation Association (JOFCA)

[1993]

- Technical assistance to National Commission for Wildlife Conservation and Development (NCWCD), Saudi Arabia for mangrove inventory and restoration through JICA scheme (to be continued until 1998)
- Support mangrove reforestation in Viet Nam, collaborated with National University of Viet Nam, Tokio Marine, Ministry of Foreign Affairs of Japan, etc. (to be continued until present)
- Support mangrove reforestation in Myanmar, collaborated with FREDA, Forest Department of Myanmar, Tokio Marine, etc. (to be continued until present)

[1994]

- Support mangrove conservation in Ecuador, collaborated with Ministry of Foreign Affairs of Japan, Forest Department of Japan, etc. (to be continued until 2002)

[1995]

- Support mangrove reforestation in Pakistan, collaborated with IUCN Pakistan (to be continued until 1996)

[2002]

- Research for mangrove restoration/conservation in Oman through JICA scheme (to be continued until 2003)

Results of plantation trials at various environments encouraged us toward restoration

An experimental nursery bed for restoration of the dead forest

Preparing *Avicennia* seeds for the nursery

Experimental plantation to restore the dead forest at Khor Farasan

An easy nursery for restoration at the second cycle

After two years, the forest was changing rapidly toward recovery, supported by plantation and improved inundation

An Inspection of the Status of Coastal Mangroves of the Southern Red Sea

Research Area: Saudi Arabia

Chiharu MIYAMOTO (Al Gurm Research Centre)

Abdullah H. AL-WETAID (National Commission for Wildlife Conservation and Development (NCWCD), Kingdom of Saudi Arabia)

Mangrove vegetation comprises an important part of coastal and marine habitats and plays a large role in the health of the coral reef systems and sabkhahs. Mangrove forests were surveyed by car along the mainland shoreline between Muwassem and mid Jeddah to gain an understanding of their distribution and status in this region. Generally, it was found that mangroves are more abundant than recorded in a 1:50,000 scale topographical photomap series. Mangroves covered most of the shoreline, where sabkhahs sustained by the topographic system of the fringing coral reef are also expected.

We confirmed that mangrove forests are directly important to the local people because they act as a fishing resource in addition to providing a food resource for camels. However, most of the mangrove forests, with the exception of those on islands, are degraded as a result of concentrated overgrazing, which has become a serious problem in recent decades. Indeed, when the causeway at Muwassem was removed, having previously been used by camels to cross the main channel of the mangrove lagoon, the mangrove forests at this location recovered significantly. Thus, it is necessary to develop control systems against overgrazing with the local and nomad people involved, as well as to establish a reservation system for the mangal on islands, which are not used for camel grazing.

Reference

Miyamoto, C. and Al-Wetaid, A. H., 1996 *Report of an Inspection in the Status of Coastal Mangal of the Southern Red Sea*. National Commission for Wildlife Conservation and Development, Saudi Arabia, Riyadh.

Avicennia trees in Farasan take a unique strategy in reproduction

The Red Sea is rich in distribution of *Avicennia* forests. In addition, 18 *Rhizophora* stands occur at 11 sites within the Saudi Coast

JICA in Kingdom of Saudi Arabia

Method for Mangrove Afforestation in Qatar

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Key words: afforestation, Al Gurm Research Centre, arid area, *Avicennia marina*,mangrove, plantation, restoration.

Research Area: Qatar

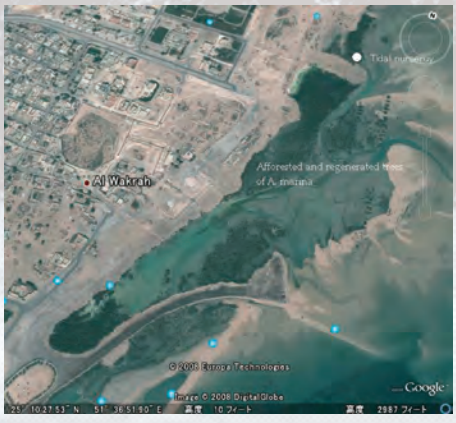
Qatar has no rivers, and the average annual rainfall is <100 mm. In such an arid environment, afforested trees such as acacia and date palms require supplemental watering.

The mangrove species *Avicennia marina* is the only native species in the Arabian Gulf. This species can grow naturally in some coastal areas that are waveless and have concentrated seawater of >4% salinity. After only a few years, young trees begin to produce seeds, and fallen seeds germinate and grow around the parent trees. As a result, the forested area increases naturally year by year.

In 1980, the Ministry of Municipal Affairs and Agriculture of Qatar began planting seedlings of *A. marina* for greening. From 1988 to 1996, the Japan International Cooperation Agency dispatched a member of the Al Gurm Research Centre, in Tokyo, to the ministry as an expert to improve its techniques and to identify new afforestation sites. Recently, these sites, including a very small experimental plot, around the Qatar Peninsula could be identified easily using Google Earth. These forests provide a rich ecosystem not only for humans but also for marine life.

The afforestation method involves the following process:

1) collecting seeds from forests (Photo 1)
2) storing the collected seeds (Photo 2)
3) removing the seed coat prior to sowing (Photo 3 and Photo 4)
4) sowing seeds in nurseries (Photo 5)
5) cultivating seedlings in nurseries (Photo 6)
6) transplanting seedlings to afforestation sites (Photo 7 and Photo 8)
7) monitoring the condition of the seedlings (overgrazing, growth of barnacles, and algal cover)



An afforestation site at Wakrah in the south of Doha (an image of Google Earth)

Reference

Suda, S., Al-Kuwari, S. I. and Al-Siddigi, M., 1995 *Mangrove Afforestation Method in Qatar*. Agricultural Development Department, Ministry of Municipal Affairs and Agriculture, Qatar, Doha.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

The Master Plan for the Restoration, Conservation, and Management of Mangrove in the Sultanate of Oman

Hiroyasu ONUMA

Project:JICA Technical Cooperation Project for the Ministry of Regional Municipalities, Environment and Water Resources, The Sultanate of Oman (2002-2004)

Implemented by: Joint Venture of Pacific Consultants International (PCI) and Appropriate Agriculture International (AAI)

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Key words: *Avicennia marina*, Master Plan Study, Coastal Management, Value of Mangrove, Conservation and Management

Research Area: Oman

Existing Mangrove Forest

Abstract

A master plan study on the restoration, conservation, and management of mangrove was conducted to formulate site-specific plans for priority sites and public awareness programs. A site survey examined natural conditions, such as mangrove forest, soil, water, flora, and fauna, and socio-economic conditions, such as fisheries and stock-raising, for 21 selected mangrove sites distributed throughout the country. Based on this survey, the surveyed sites were classified into different zones according to the topography and oceanography of each site. In addition, the value of mangrove at each site was studied and a management plan for each site was formulated. As a result of the study, the establishment of the Qurm Environmental Information Center (QEIC) was recommended in order to coordinate the management activities of various organizations and local communities.

Action Plan in the Human Subsistence Study

The major roles of the proposed QEIC are (i) to collect and compile necessary data on the conservation and management of the mangrove ecosystems in Oman and (ii) to provide necessary facilities and materials for implementing public awareness and education programs on mangrove and the coastal environment for school children, residents, visitors, and tourists. This human subsistence study will promote information sharing and the utilization of shared information by local communities.

References

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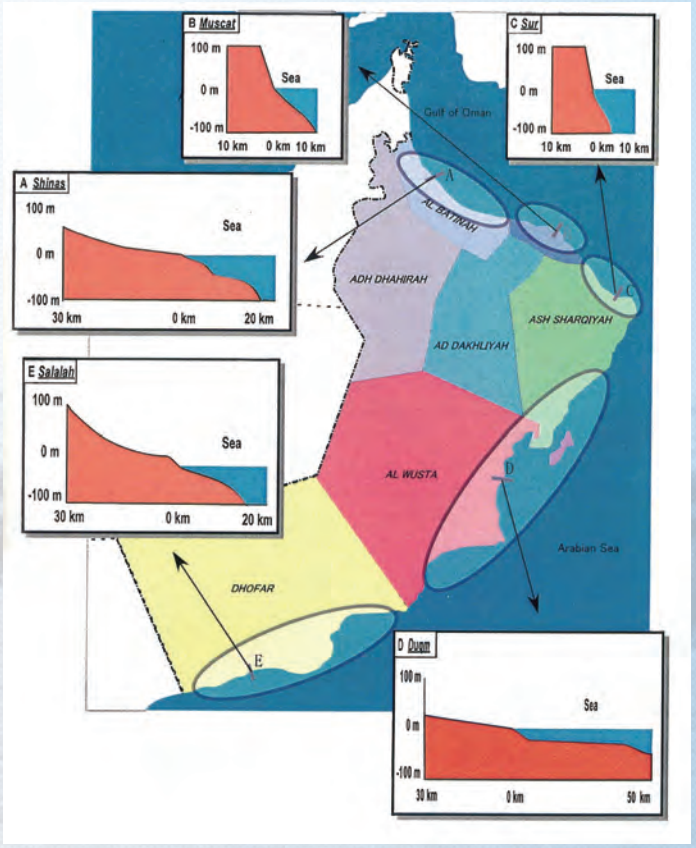
International Union for Conservation of Natural Resources, 1986-1991 *Oman Coastal Zone Management Plan*. Ministry of Commerce and Industry.

Mangrove Sites and Potential Areas



Classification of the Study Area and Cross Section

Plantation by School Children

Maintenance by Local Communities

A Handbook for an *Avicennia marina* Nursery and Transplantation: Technical Guidelines for Afforestation

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Key words: *Avicennia marina*, Mangrove Forest, Nursery, Transplantation

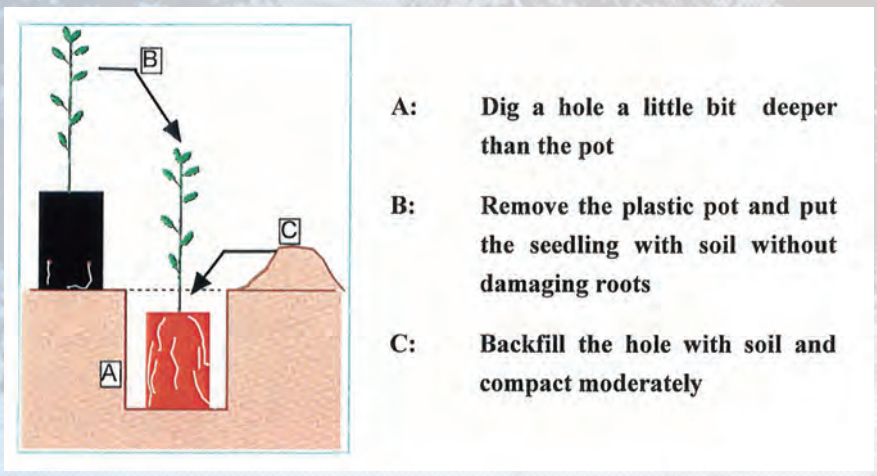
Research Area: Oman

Abstract

The general status of mangrove forests in Oman was described for each mangrove site based on the results of a field survey. Detailed information on seed collection, such as timing, site, treatment, and storage, was described based on actual field experience with the method of seed sowing. The nursery operation was also described in detail, including site selection, irrigation method, facility design, necessary shading, operation, and maintenance, with effective photographs and drawings. The method of transplantation was explained with detailed information on the planting site and time, necessary equipment, actual procedure, and necessary maintenance. Finally, the method of direct sowing was described with information on the sowing time and procedure.

Action Plan in the Human Subsistence Study

The information and experience obtained through the above-mentioned study could be utilized effectively in the current human subsistence study.



Transplanting Procedure

Flowers of *Avicennia marina*

Seeds of *Avicennia marina*

Tidal Irrigation

Pump Irrigation

Germination 1 week after sowing

Seedling 4 months after sowing

Study of Gray Mangrove (*Avicennia marina*) Afforestation for Greening a Desert Coast: Gray Mangrove Afforestation on the Banks of an Artificial Channel across a Sabkha and Established Biotic Community.

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Key words: *Avicennia marina*, Germinating seed, Dredged channel, Mangrove planting, Sabkha

Research Area: United Arab Emirates

Abstract

Seedlings of the gray mangrove were planted on the banks of an artificial channel that had been dredged across a sabkha to allow seawater to flow into it. Although 56.7% of the seedlings survived, and had become established on the banks over the past 5 years, their growth rate has been lower than that of mangroves planted by direct seeding in the United Arab Emirates. Seedling mortality was strongly affected by erosion, sand accumulation, seedling weakness, and sandstorms. Benthic plants, fish, and animals in the channel and mangrove-planted area were studied. Parts of the channel banks had patches consisting of three species of sea grass, and a number of fish and benthos inhabited the channel. The surface soil of the mangrove-planted area was inhabited by many mud creepers and pea-sized crabs. During the observation period, it was noted that the seawater in the dredged channel had been enriched during the previous five years by various aquatic animals and the shedding of dead mangrove leaves. These results show that planting gray mangroves along the dredged channel has allowed a number of species to become established on a sabkha within a five-year period.

Action Plan in the Human Subsistence Study

Information and experience obtained through the above-mentioned study could be utilized effectively in the current human subsistence study.

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Mangrove planted on the banks of an artificial channel dredged across sabkha
(an image of google earth)

Nursery of mangrove seedlings

Mangrove planted on the banks

Mangrove grown on the banks

Bird species flown to the site

A Conservation Plan for Dugong along the Northeastern Coast of the Red Sea in the Kingdom of Saudi Arabia

Interview for dugongs with a fisherman

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Key words: Conservation Plan, Dugong, Red Sea, Saudi Arabia

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Research Area: Saudi Arabia

Summary

A survey of the dugong population (abundance) and distribution in the Saudi Arabian Red Sea was conducted in 1987 under the guidance of Australian scientists. The results of the survey were published as a MEPA (Meteorological & Environmental Protection Administration, Ministry of Defense & Aviation) Technical Report (DUGONGS, Volume1, 2, 1989). Within this report, it was recommended that dugong protected areas be established“ in and around Al-Wajh Bank” of the Saudi Arabian Red Sea. Meanwhile, the NCWCD (National Commission for Wildlife Conservation and Development) implemented a Study on the Coastal/Marine Habitat and Biological Inventories in the northern region of the Red Sea in cooperation with JICA (Japan International Cooperation Agency) during 1998–2000. The study was completed successfully, and Al-Wajh Bank was chosen as one of the model sites in the area. However, the NCWCD was unable to obtain sufficient data of the dugong populations in this region to develop marine protected area management programs for this species. Therefore, the NCWCD conducted an examination of the status, morphology, behavior and behavioral ecology of dugong in and around Al-Wajh Bank in 2002.

A healthy dugong habitat plays an important role in relation to human populations. Dugong habitats include seagrass beds (the only food source for dugongs), mangrove vegetation on soil or sand, coral reefs and fish. These habitats act as fisheries resources and play a role in environmental education. Such ecosystems should be protected as one of our precious common resources.

Dugongs were classified as a vulnerable species for extinction by the IUCN-World Conservation Union in 1982. In addition, they are listed in Appendix I of the Conservation on International Trade in Endangered Species of Wild Flora and Fauna. Dugongs have been conserved according to Rules and Regulations of Wildlife and Natural Resources Conservation in the Kingdom of Saudi Arabia since 1996.

To develop an effective dugong management plan, it is important to gain an understanding of dugong population sizes and dynamics, dugong ecology in their behavioral spheres (home ranges), and the distribution and abundance of seagrass, the only dugong food source. A summary of the current ecological and physiological information on dugongs, such as morphology, behavior and behavioral ecology as well as physiology, was compiled from existing reports.

The worldwide dugong population is estimated to comprise 100,000 individuals in the Pacific and Indian Oceans, 80,000 around Australia, 8,000 in the Arabian Gulf, 2,000 in the northeastern Red Sea, and 300 in and adjacent to the Al-Wajh Bank area. A map of dugong sightings in 1987, 1998–1999 and 2002 and their habitats was constructed. Dugong sightings did not always correspond with seagrass beds, but they were concentrated into a small number of well-defined areas, such as in and adjacent to the Al-Wajh Bank. The daily routine of a dugong consists of searching for food, eating, resting and sleeping. The abundance and type (species) of seagrass are important factors of dugong feeding behavior.

Aerial transect surveys and bio-telemetry surveys are used as basic methods to understand the dugong population and ecology. An aerial transect survey was conducted in and adjacent to Al-Wajh Bank from 4–7 February 2002. The Dugong population in this area was estimated to be greater than 260. In addition, on February 2 and 8–13, 2002, 18 coast guards were interviewed on the status of dugongs to gain an understanding of dugong behavioral ecology.

To develop a management plan for dugong conservation, surveys will be conducted on the following five aspects of dugong ecology: population dynamics, feeding ground environment, characteristic behaviors, physiology and ecology. The contents and methods of the surveys have been arranged, and they will be conducted in cooperation with local activities and initiatives. We proposed a schedule of surveys prioritized with respect to the importance of their outcome in preparing a dugong management plan.

Immediate actions are necessary for dugong conservation in the Red Sea. These actions should be carried out in advance of studies or research action to avoid delay. The primary threat for dugongs in the Red Sea is habitat reduction. Seagrass beds are lost as a result of silt runoff from the land to the sea. The second largest threat to dugongs is net fishing. The most accessible method of dugong conservation is to forbid actions that threaten seagrass beds and dugongs directly, and to establish strictly controlled protected areas. The boundaries of protected areas must coordinate with other conservation plans for natural and social environments. Dugongs appear to be a good environmental indicator species. Protection control must include the redesigning of gill nets and fixed nets such that they release dugongs, as well as surveys and other measures to conserve seagrass beds, and restrictions to the passage of sea vessels into protected areas.

Finally, it is necessary to collect information from fisheries to determine the economical and social importance of fishing areas and net fishing in dugong protected areas. Specifically, we must consider the balance between the social significance of fisheries and their influence on dugongs. Thus, our survey must account for its social and economic influences in relation to fishermen and fishing villages.

Work plan for This Project

A study of the habitable environments of dugongs including the mangrove ecosystem along the southern coast of the Red Sea in the Kingdom of Saudi Arabia

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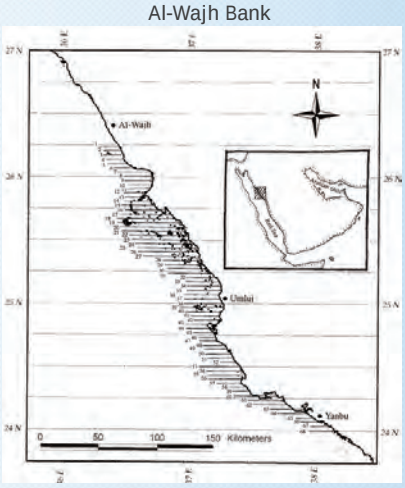
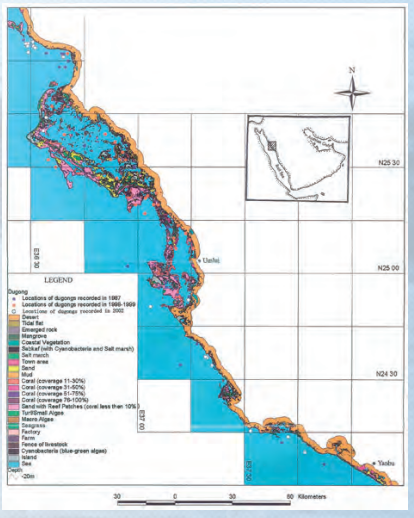
Stranding of a dugong on the coast of Al-Wajh Bank



Location of aerial transect survey (JICA 2002)



Sighting points of dugongs by aerial survey (JICA 2002)

Fisherman on the coast of Saudi Arabian Red Sea

NCWCD aircraft used by aerial survey, captain and author

Long-term Maintenance of Arid Mangroves: Mangrove Distribution and Use in Iran and Pakistan

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Key words: Mangrove, Geo-ecology, Arid coast, *Avicennia marina*, Branch harvesting

Research area: Iran and Pakistan

Photo 1. *Avicennia marina* as the feed for camel in Queshim island in Iran (Photo by S. TAKATSUKI)

Research production

My laboratory is conducting the following examinations with The International Society for Mangrove Ecosystems (ISME) and other institutes: 1. Mechanism and field based geo-ecological studies of mangrove habitat dynamics. 2. Mangrove habitat dynamics and sea level changes in the Western Pacific Ocean and Southeast Asia. 3. Rehabilitation of degraded mangrove habitat using an environmental approach. 4. Evaluation of the role of environmental protection measures for mangroves against natural disasters. 5. Construction of a mangrove GIS database.

Research plan for the Arab Livelihood project

A mangrove is a forest ecosystem that exists in the upper half of the sea tidal zone. Mangroves play very important roles in arid regions because they constitute the only dense, deep green forests that are rich in nutrition in such areas. Despite the beauty and richness of these ecosystems, their habitat size is relatively small. Our research shows that, according to the Holocene Sea-level fluctuation, most recent mangrove habitats were developed and maintained in the last 1000 to 2000 years. The local people have been using and maintaining these systems for nearly 1000 years. The sustainable use and management of ecosystems is an autonomous effort in many arid regions.

Our team describes the mechanisms of existence, or extinction, for mangrove habitats that we are examining in selected coastal areas of Iran and Pakistan using a physical and sociological approach. In doing so, we are able to determine how these mangroves have existed for so long. By examining whether the community has played an autonomous stabilization role, based on a geo-ecological understanding of the mangroves, we can gain an understanding of the knowledge of the local people.

For this purpose, the upcoming study will include: 1. A mangrove habitat distribution analysis and a GIS database constructed by satellite image analysis. 2. Field investigations to clarify the mangrove habitat maintenance mechanisms in relation to sea-level fluctuations, geo-ecological dynamics and regeneration mechanisms. 3. Evaluation of the mangrove biomass in particular habitats. 4. A quantitative assessment of the use of mangrove forests for fodder, fuel, etc. 5. Interviews with local people to collect data on the traditional use of mangroves.

Action plan

The GIS database construction is currently underway (Fig.1). We have also conducted some small pilot field studies (Photo 1, 2). We will conduct full field studies in selected mangrove habitats in Iran and Pakistan based on the GIS database. The first field study will be conducted over 3–4 weeks on the Iranian coast near the Arabian Gulf.

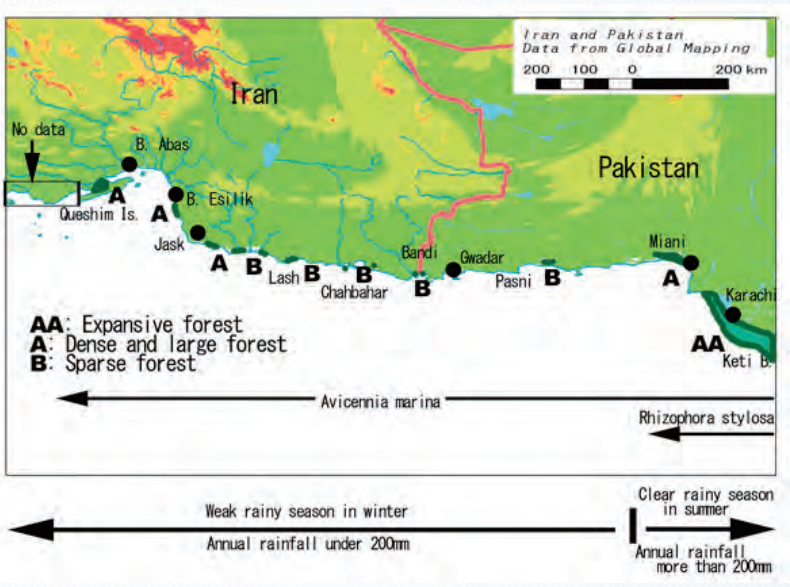

Fig. 1. Mangrove distribution at Iran and Pakistan coast

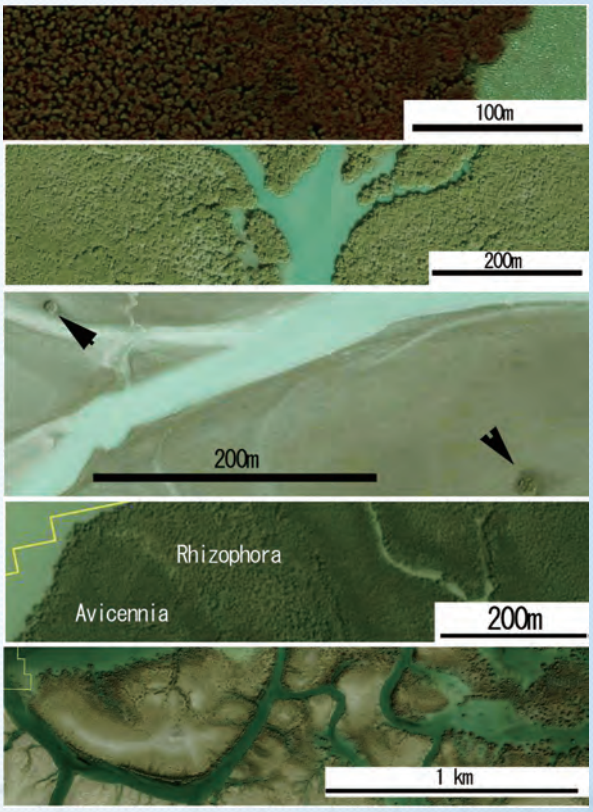

Fig. 3. Detal of typical mangrove habitat in selected area. Top to bottom: Jask, Yekder, Surak, Miani, Keti Bandar

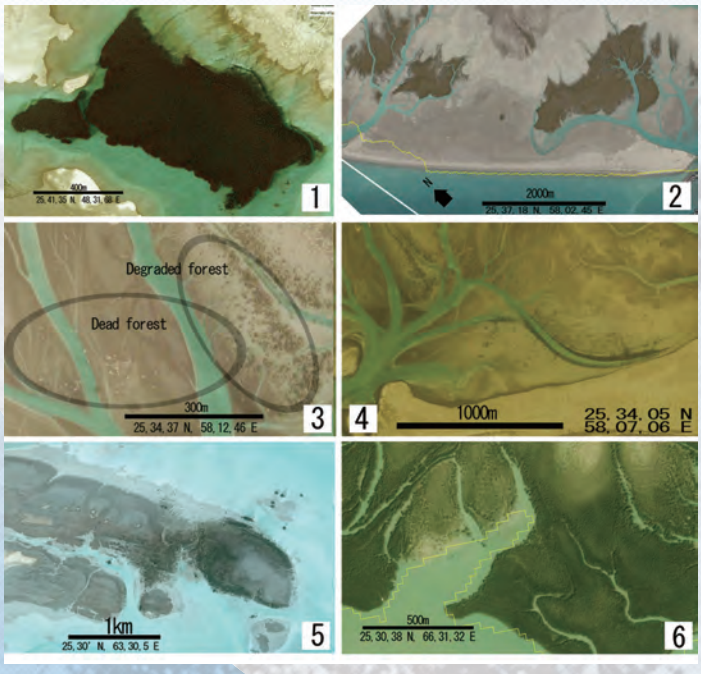

Fig. 2. Samples of mangrove habitat from west to east.
1: Jask, 2:Yekder, 3:Surak, 4:Surak, 5:Pasni, 6: Miani

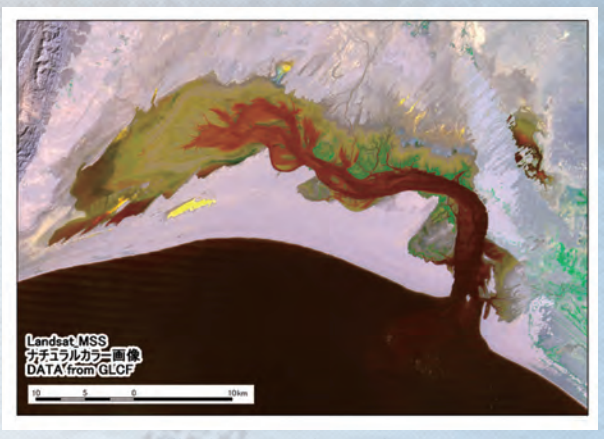

Fig. 4. Satellite images of the good mangrove forest. Miani hol in Pakistan

Photo 2. *Avicennia marina* as the feed for cattle in Karachi, Pakistan

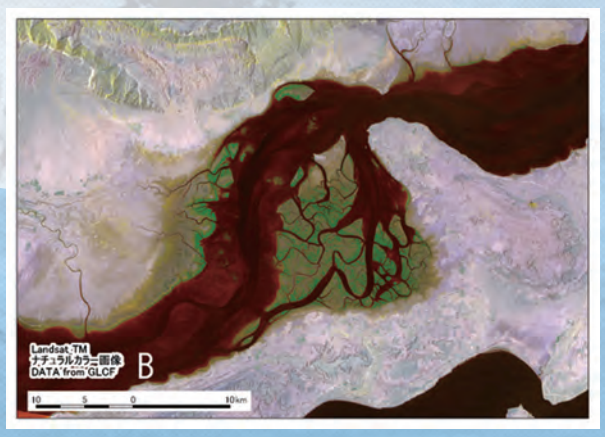

Fig. 5. Satellite images of the good mangrove forest. Quesim island in Iran

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Ecological and Genetical Studies of Mangrove (*Avicennia marina*) Forests in the Sultanate of Oman

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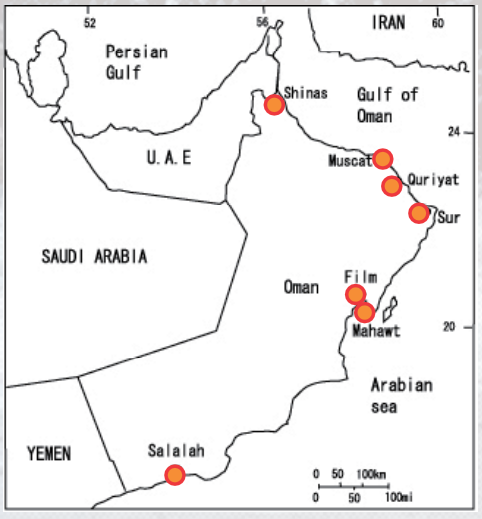
Research Area: Oman

Ecological and Genetic Studies of Mangrove (*Avicennia marina*) Forests in the Sultanate of Oman

The coastal area of the Sultanate of Oman, located at the eastern end of the Arabian peninsula, was once covered by expansive and dense mangrove forests of *Avicennia marina*. However, most of these ecosystems were destroyed by overuse with regard to fuel woods and overgrazing by livestock. As a result, only small patches of mangrove forest have survived at studded mouths of wadi and lagoons along the northeastern shoreline. As most of Oman is desert, mangrove forests comprise an important ecological resource, and the conservation and development of these forests are a crucial aspect of natural resources management.

In 2003, we examined forest structure and measured stomatal conductance and transpiration rates in seven *A. marina* populations along the coastal region of the Sultanate of Oman. In addition to these ecological analyses, DNA analyses were conducted using the CTAB method, and DNA polymorphisms were measured using the RAPD method.

The transpiration rate of *A. marina* was regulated through changes in stomatal conductance along gradients of drought or saline stress associated with increases in tidal inundation level. Differences in forest structure were observed between systems in northern regions and central and southern regions. In the northern area, tree density was high, and the maximum height of *A. marina* was approximately 6 m. In contrast, in the central and southern areas, the crown projection area was large, and maximum tree height reached over 8 m. Tree growth was affected by annual changes in precipitation and differences in temperature across sites. Furthermore, the regeneration and establishment of seedlings were affected by canopy gap formation and fresh seawater inundation.



Study Sites in Oman

Genetic distances between the northern and central populations and the southern population were larger than those between the northern and central populations, indicating the importance of considering the transplantation of both seeds and seedlings for afforestation efforts. Moreover, genetic diversity was significantly positively correlated with forest area; therefore, to conserve genetic diversity, it is crucial to maintain *A. marina* populations within a large forest area.

Forest structure

In northern forest, Hmax is 6 to 7 m with high tree density

Survey site	Seedlings (Nha^{-1})	Small trees(Nha^{-1})	Medium trees(Nha^{-1})	Large trees(Nha^{-1})	Diameter mean(cm)	Height max	Height max(cal.)	CPA1) mean ($m^2 N^{-1}$)	CPA1) sum ($ha\ ha^{-1}$)	Basal area ($m^2 ha^{-1}$)
Shinas	100000	5525	875	125	3.19	5.72	7.00	2.15	1.41	4.04
Quriyat	125	4800	1150	0	3.63	4.50	5.52	2.74	1.63	8.85
Qurm	400	4280	760	0	4.65	4.77	5.40	2.34	1.18	13.20
Sur	103400	8725	100	25	2.16	6.43	7.12	0.97	0.86	7.67
Film	2040	2400	0	0	4.46	2.95	3.95	0.77	0.13	5.83
Mahawt(N)	2800	15600	5200	0	3.45	4.89	6.31	2.15	5.03	36.77
Mahawt(S)	0	525	700	850	9.96	8.12	8.90	12.71	2.64	30.77
Salalah	–	–	–	–	8.84	7.11	10.50	31.88	–	–

※Seedlings :0<H<1.0
small trees:1.0<H<3.0
medium trees:3.0<H<5.0
large trees:5.0<H

Size of matured forest in southern territory will be larger than that in northern forest.

In southern forest, Hmax reaches over 8 to 10 m with big CPA

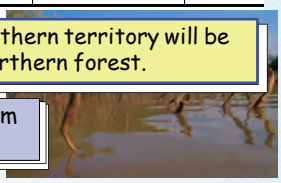


Fig. 1. Site description

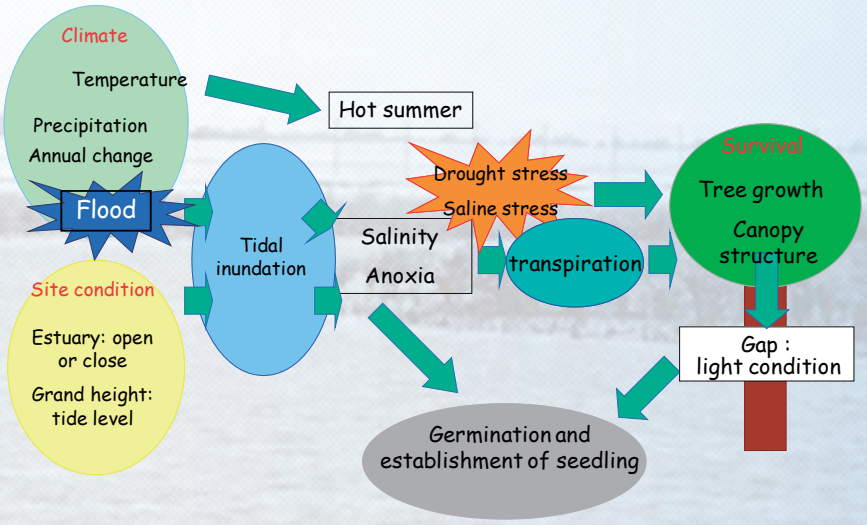


Fig. 2. Effects of environmental stresses on physiological processes

Genetic difference

Most of mangrove forests along the Arabian peninsula are destroyed by artificial management and the global change.

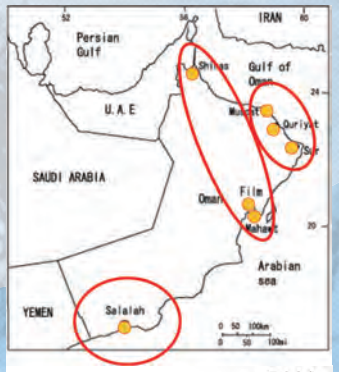
Avicennia forests can survive only at studded month of wadi and lagoons.
Geographical isolation of such extant forests

Small insects are important for pollination: entomophilous
Restriction of dispersion by buoyant and viviparous seed

Genetic difference between Salalah and other northern populations

Effects of genetic disturbance

Consideration of seed transportation between north and south



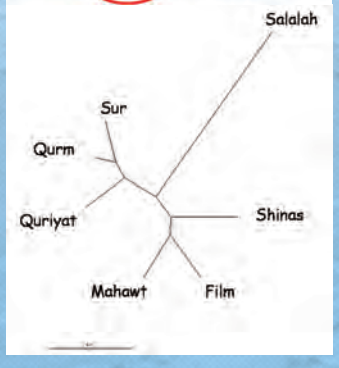


Fig. 3. Cause of genitic difference

Local Mangrove Resource Use on Kilwa Island, Southern Swahili Coast

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Key words: maritime environment, society and culture in Swahili and Arab

Research area: Swahili Coast

Kilwa Kisiwani

is a small lagoon island just off the southern Swahili coast of Tanzania. It is 12 square kilometers in area and 23 kilometers in circumference. The island has, at most, a thousand inhabitants. Situated at the mouth of three rivers, Kilwa Kisiwani is surrounded by two kinds of seas: between the island and the continent lies a mangrove lagoon and, on the other side, the open sea with a fringing reef (Fig. 1).

Kilwa Kisiwani is located at latitude 9 degrees south, which places it within the East African monsoon region. The wind blows all year long. The island is three hundred kilometers from Dar es Salaam, the nearest metropolitan area in Tanzania. Poor road conditions render the island essentially isolated. As a result, Kilwa Kisiwani is virtually untouched by modern economic development. Residents of the island maintain an almost completely self-sufficient economy based on fishing and gathering other food from the surrounding seas, along with limited farming.

Although Kilwa Kisiwani is currently home only to a small seashore village, during the Middle Ages it flourished as an influential Islamic trading port known as Kilwa Kingdom. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has classified a number of stone buildings from the Kilwa Kingdom era as World Heritage sites (UNESCO, 1981).

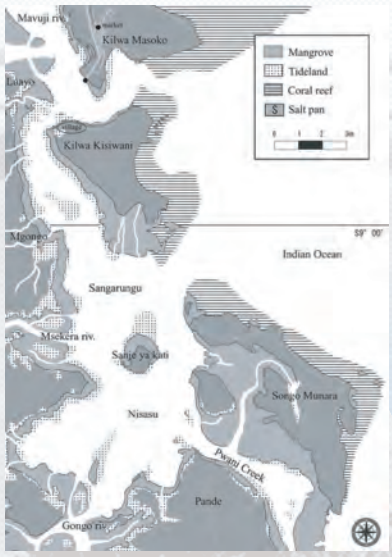

Fig.1. Natural Environment of Kilwa Island

The maritime environment of Kilwa Island can be divided into three ecological sea zones (Fig. 2). Eco-zone 1 is a lagoon covered with mangroves. The water here is shallow and calm, with little wind or wave activity. The floor of this lagoon is comprised mainly of mud. Eco-zone 2 is the open sea with a fringing reef. This zone is characterized by deep water, rough waves, and strong winds influenced by the monsoons. The sea floor in this zone is comprised mainly of coral and sand. Eco-zone 3 is the intermediate sea between the lagoon and the open sea. This zone is characterized by a combination of the qualities seen in zones 1 and 2.

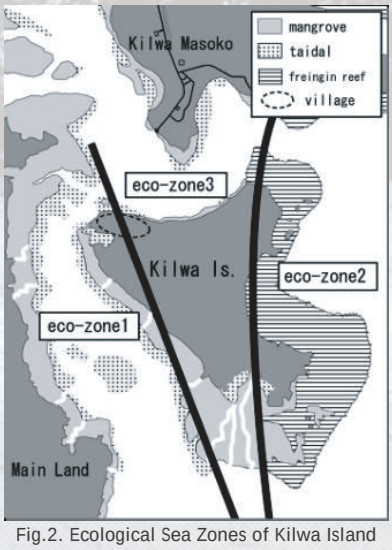

Fig.2. Ecological Sea Zones of Kilwa Island

Local Mangrove Use on Kilwa Island, Southern Swahili Coast

The Swahili coastal region is home to one of the richest mangrove resources in Africa. The Tanzanian mangrove forest has been well preserved; a report by The United Nations Environmental Program's World Conservation Monitoring Center (UNEP-WCMC) indicated that the area in Tanzania covered by mangroves remained nearly unchanged from 1990 to 2000, encompassing 1,096 ㎢ in 1990 and 1,081 ㎢ in 2000. The southern coastal region of Tanzania around Rufiji and Kilwa comprised 65% of the domestic mangrove area, or 730 ㎢ .

Stone Pillars of Great Mosque

House built with Mangrove Pole

Seine Fishing (*kavogo*)

There are eight species of mangrove in Kilwa. Inhabitants use these mangroves in two primary ways: direct use and environmental use. Direct uses include employing mangrove poles in the construction of buildings, in shipbuilding, in the manufacture of fishing gear, as firewood, for medicinal purposes, and so on. Environmental uses include utilizing the mangrove sea as a fishing ground and for transportation routes. Previous field research identified seven forms of direct mangrove use and five forms of environmental use.

A delicate balance characterizes these patterns of mangrove use. Immoderate logging might damage or destroy the mangrove environment, but prohibition of logging in the name of conservation would result in a dearth of mangrove poles for direct use. Even though this balance seems fragile, the mangrove environment in Kilwa has not suffered from direct use by the local residents. This apparent equilibrium may reflect some combination of the low population density (12 persons/ km^2) of the southern coastal region where Kilwa is located and local residents' knowledge of mangroves, as well as their understanding of the importance of mangroves to their lives.

Recent years have witnessed the development of infrastructures and the growth of tourism in the area. Future research should explore how this changing social situation will impact the relationship between the Kilwa people and mangrove resources.

Mangrove Forest

Mangrove Fence Fishing (*Wando*)

Main Focus of this Project

This project will involve a study comparing the Swahili coastal region and the Red Sea coastal region, two areas where residents' lives are profoundly dependent on maritime resources, especially mangroves.

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Middle Size Boat (*Mashua*)

Relationships between Humans and One-humped Camels in the Coastal Zones of the Arid Tropics: An Anthropological Case Analysis of the Beja on the Red Sea Coast of Eastern Sudan

Research Area: Sudan

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Keywords: mangrove foliage, camel, coastal resource use, Beja, Sudan

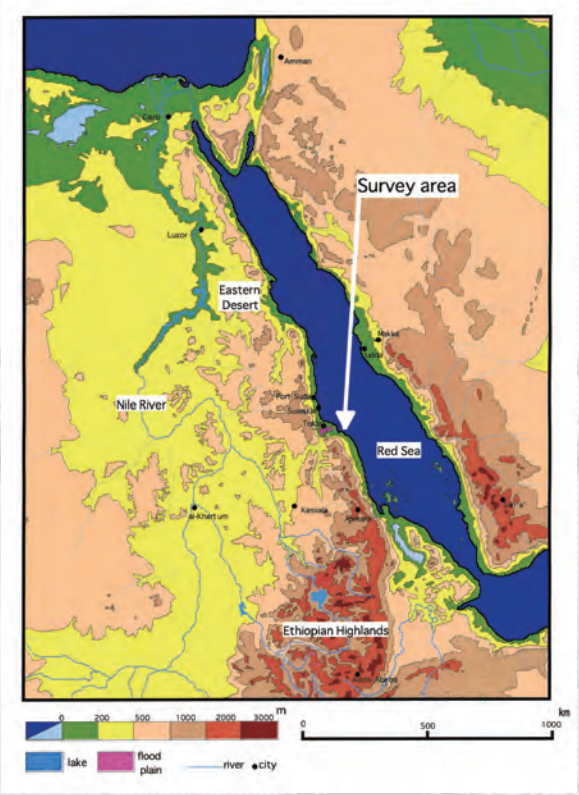

Fig. 1. Survey area

This study adopts an anthropological perspective to illuminate the relationships between humans and one-humped camels in the coastal zones of the arid tropics via a case analysis of the Beja on the Red Sea coast of eastern Sudan. The Beja live in an area stretching across Egypt, the Sudan, and Eritrea that is surrounded by the Red Sea, the Nile River, the Ethiopian highlands, and the Eastern Desert of Egypt. This area was estimated to have a population of 620,000 in 1970. The focus village of Agetai on the coastal plain of Sudan has a population of approximately 2000 and covers an area of 3 km in length by 5 km in width. Fieldwork was conducted from 1992 to 1997.

The pastoral system of the Beja focuses on one-humped camels, which rely on halophytes and mangroves, eaten on grasslands and shrublands used exclusively by camels. This system characterizes the distinct human-livestock-plant relationships of the coastal zones of the arid tropics. The camels facilitate human habitation along the coast because of their ability to drink salty water. Camels also play an invaluable role in the process of appropriating and transporting various coastal resources, with their outstanding ability to walk on both soft substrates (mud and sand) and coral-rich substrates in the littoral and sublittoral zones. The Beja target driftwood, mangroves, gastropods, and fish in gathering and fishing activities. The principal types and purposes of resource use concern food; resources are used mainly for subsistence and as materials for daily life. However, the opercula of gastropods are also important for their use in incense and perfume, which have long been traded across broad networks and have provided cash income to a people suffering from hunger under recent drought conditions.

Raised coral reef islands are utilized as grasslands and shrublands that are available only for camels. The mangrove and coral reef associated ecosystems of the islands also serve as gathering and fishing sites supplying gastropods and fish. Physical environments, such as the coral reef topography and tidal conditions, determine how the islands are used by camels; i.e., frequently accessed islands with long stays, frequently accessed islands with short stays, infrequently accessed islands, and inaccessible islands. Therefore, the use of coastal islands for camels has limited overexploitation of these biological resources.

The use one-humped camels for diverse purposes has created multi-dimensional relationships between humans and camels in the coastal zones of the arid tropics. The value of camels in these zones cannot be understood solely in terms of the pastoral production system. The camels convert energy contained in plant products that humans cannot eat into energy available for humans as milk and meat. Furthermore, the Red Sea coastal zones are crossed by two ecotones: the transition between arid and wet areas that stretches across the African continent from east to west and that between land and sea that stretches from north to south. The relationships between humans and

one-humped camels in these zones serve as “a safety device for adapting to changes in natural environments.” Mangrove ecosystems in the coastal zones of the arid tropics represent an important source of energy for the surrounding terrestrial ecosystems. This area is rich in biodiversity, and there is high potential for sea and pastoral food production by reforesting mangroves as fish nurseries and protecting them from foraging. Many residents of the coastal zone of the arid tropics depend on sea products obtained by hunting, gathering, and fishing, such as fish, shells, dugongs, dolphins, and sea turtles. Therefore, in the development of arid land food production, sea products should be considered as principal elements in future diets.

Research Plan

1) Anthropological study of human-camel relationships;
2) Mangroves as fish nurseries to protect these environments from foraging;
3) Assessment of the environmental effects of development programs on the coastal zones of the arid tropics.

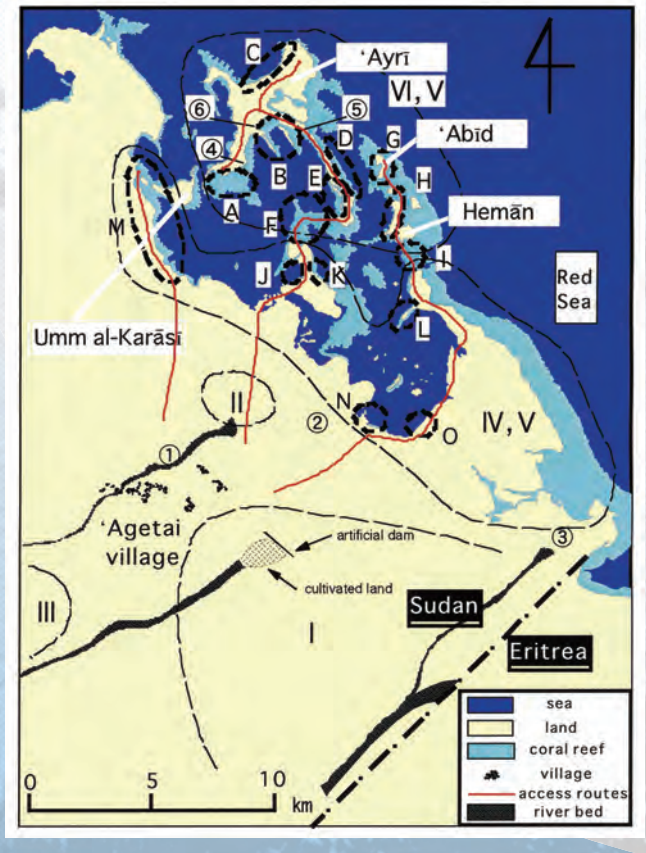

Fig. 2. Resource/land use and access routes to the coral reef islands by camels.
(1): wells on dried riverbeds of seasonal streams
(2): a natural pond on low ground beside raised coral reefs
(3): wells at which the surface runoff of seasonal streams terminates before reaching the shoreline
(4): cisterns at an archaeological site on a coral reef island
(5): wells near the shoreline of a coral reef island
(6): wells on low ground on a coral reef island; I: grasslands on the coastal plain; II: shrublands at which the surface runoff of seasonal streams terminates; III: shrublands at the inland margin of salt marshes; IV: salt marshes near the shoreline; V: mangrove communities in the littoral zone; VI: grasslands and shrublands of raised coral reef islands; A~O: fishing and gathering sites.

Fig. 3. Coral reef flat (Site F) between Ayri island (Space 2) and the mainland

Fig. 4. Young male collecting gastropods on fringing reef flat, and shells left on the shore at Site N (P8)

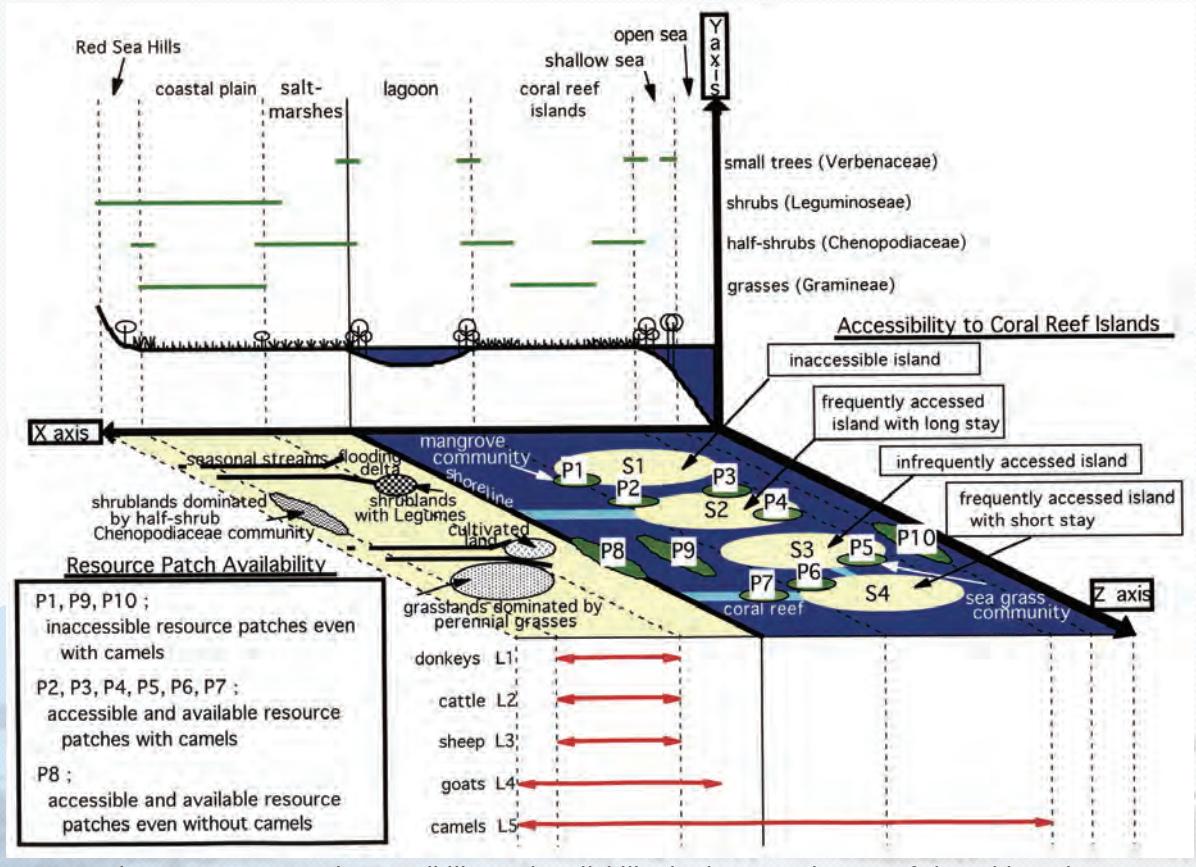

Fig. 5. Resource patch accessibility and availability in the coastal zones of the arid tropics

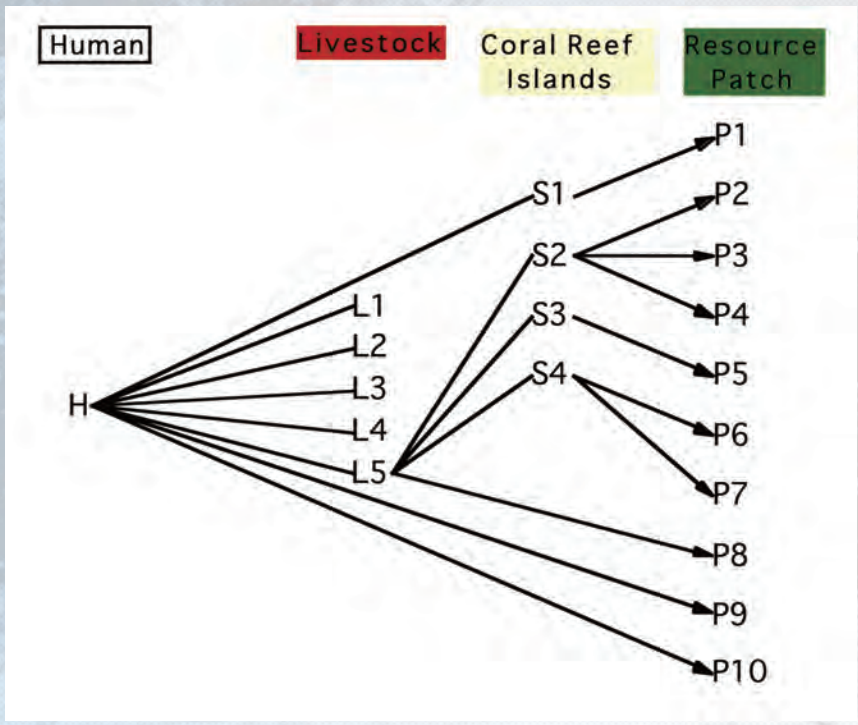

Fig. 6. Outline of resource-patch accessibility and availability.

H: humans, L1: donkeys, L2: cattle, L3: sheep, L4: goats, L5: camels; S1: Umm al-Karasi, S2: Ayri, S3: Abid, S4: Heman; P1, P2, and P6: mangrove communities in shallow seawater along island shorelines, P3: mangrove community along an island shoreline facing the open sea, P4 and P5: seagrass communities along island shorelines facing the open sea, P7: seagrass community on coral reef flats connecting islands facing the open sea, P8: mangrove community in shallow seawater along the mainland shoreline, P9: mangrove community in the middle of the shallow sea, P10: mangrove community near the open sea.

Fig. 7. Old camel herder leading camel herd (L5) from Ayri island (S2) to the mainland

Fig. 8. The camels are herd for more than several months in Ayri island

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Coastal Resource Use by Camel Pastoralists: A Case Study of Gathering and Fishing Activities among the Beja in Eastern Sudan

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This paper attempts to reconstruct subsistence activities among the Beja, camel pastoralists living along the Sudanese coast of the Red Sea, focusing on their coastal resource use.

I reveal, as a result of participant observation, that they target driftwood, mangroves, gastropods, and fish in gathering and fishing activities. The principal types and purposes of resource use are as a resource for food; a resource as a means of subsistence; and a resource for daily life materials.

I also show how the one-humped camel plays an invaluable role in the process of appropriating and carrying these resources, because it has an outstanding ability to walk on both soft substrates (mud and sand) and coral-rich hard substrates in littoral and sublittoral zones.

Key words: Beja, camel pastoralism, subsistence, coastal ecosystems, resource use.

1. INTRODUCTION

A variety of resources on many seashores throughout the world have been targets of human use, depending on particular circumstances of time and space. Hunter-gatherers, agriculturalists and fishermen have lived on the shore, a part of larger coastal ecosystem, which is an ecotone between the land and sea.

During the 1980s and 1990s, there was increasing recognition that management of subsistence activities is necessary for conservation or sustainable uses of natural resources, especially in mangrove and coral reef communities of tropical shores. We need to examine the ways in which human resource use affects coastal ecosystems, and in which environmental factors constrain human societies and cultures, in addition to biological productivity of the natural system itself (Tanaka 1986; Japan International Cooperation Agency 1990; Akimichi 1995; MaGinn 1999).

At the same time, pastoralist research also moved from a cultural ecology to a political ecology framework in the 1990s (Fratkin 1997). There is now a larger concern with the process of resource use as well as its outcomes. However, relatively little attention appears to be paid to how pastoral peoples interrelate with coastal ecosystems, and particularly what kinds of resources they use, except for a few pioneer studies (Chapman 1976; Takatsuki 1980). Examining the degree of multi-resource exploitation and the degree of dependence on non-pastoral products offers the possibility of within-group and between-

group comparisons of pastoral production systems (Salzman 1972; Dyson-Hudson & Dyson-Hudson 1980).

I focus on coastal areas as living ranges from diversified points of view, in attempting to reconsider the subsistence economies of camel pastoralists[1] who have survived in arid lands. In this paper, as a first step, I try to analyze their gathering[2] and fishing activities, and to point out the considerable importance of the camel's role in the process of coastal resource use.

2. STUDY PEOPLE

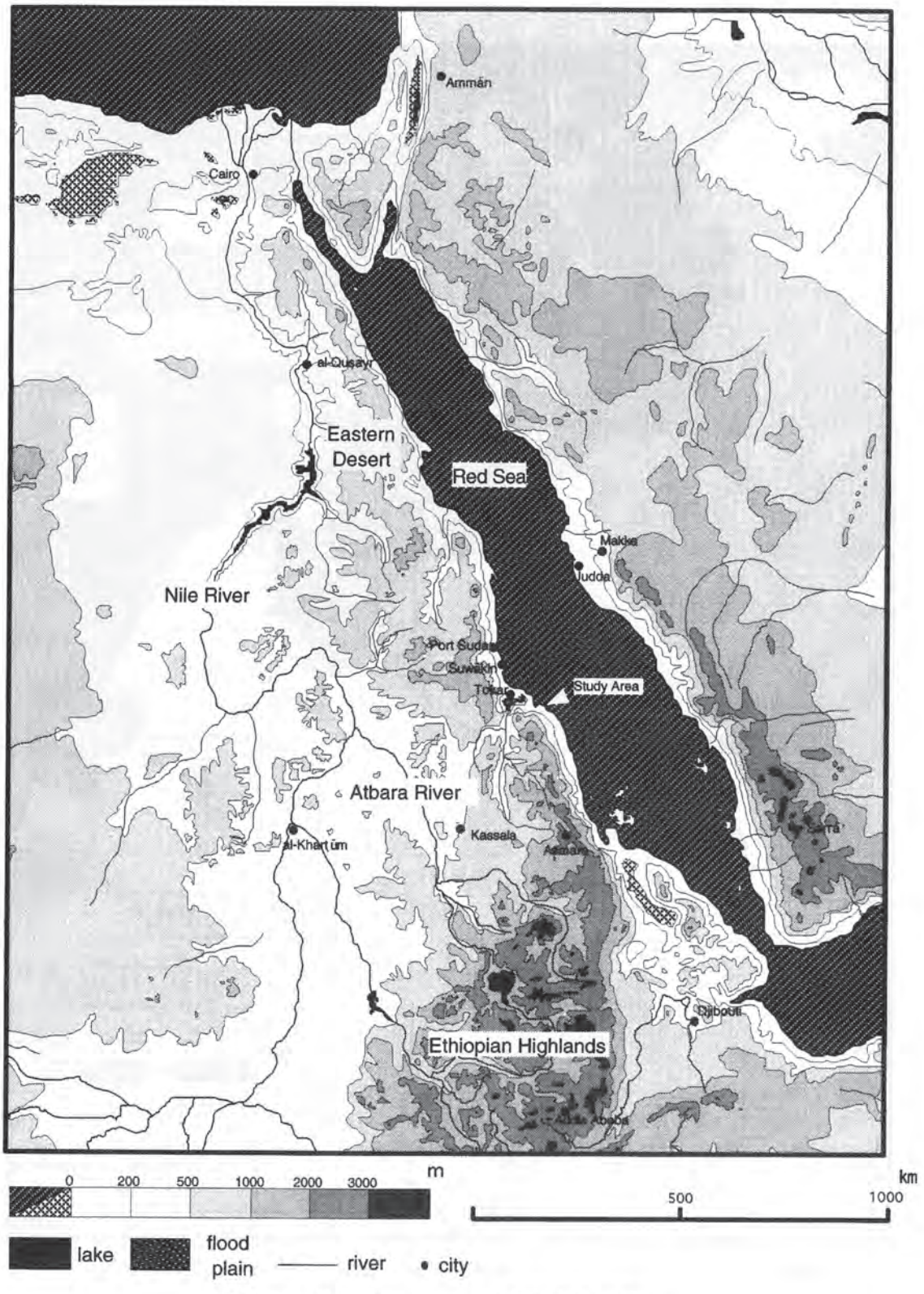
The Beja live in an area surrounded by the Red Sea, the River Nile, the Ethiopian highlands and Eastern Desert of Egypt, stretching over three countries (nation-states): Egypt, the Sudan, and Eritrea. The population was estimated as 620,000 in 1970 (Paul 1954; Holt 1960; Morton 1993). It was first mentioned in Arabic as *al-Bujat* by al-Wāqidī in the seventh century, and *al-Bujat* is also written as *al-Bujāt*, *Bujāh*, *al-Bujā* or *al-Bujāwat* in other Arabic sources. This name actually would have historical connection with *Bega* in Gəʿəz, *Blemmyes* in Greek, and *Medjay* in Egyptian (Nawata 1997). Either Tibḍaawye (the northern branch of Cushitic) or Tigre (the north Ethiopic branch of Ethiopic Semitic) is spoken as a first language by most of the Beja, and Arabic (Egyptian or Sudanese dialects) is also widely used (Moseley & Asher eds. 1994)[3].

Economic production of the Beja depends mainly on their herds of camels, cattle, sheep, and goats. High frequencies of lactase persistence are observed in large populations. Although many people practice some cultivation of sorghum (*Sorghum* spp.) and pearl millet (*Pennisetum typhoideum* (Burm. f.) Rich.), some also engage in fishing on the seashore. It is estimated that 75%–90% of the animal wealth of the people was totally lost through death in the drought of 1984–86. This caused extensive migration to urban centers, and raised the dependency on the market economy and relief food supplies (Crossland 1913; Bayoumi *et al.* 1982; Bakhit 1984; Cutler 1986; OXFAM 1990; Hjort & Dahl 1991).

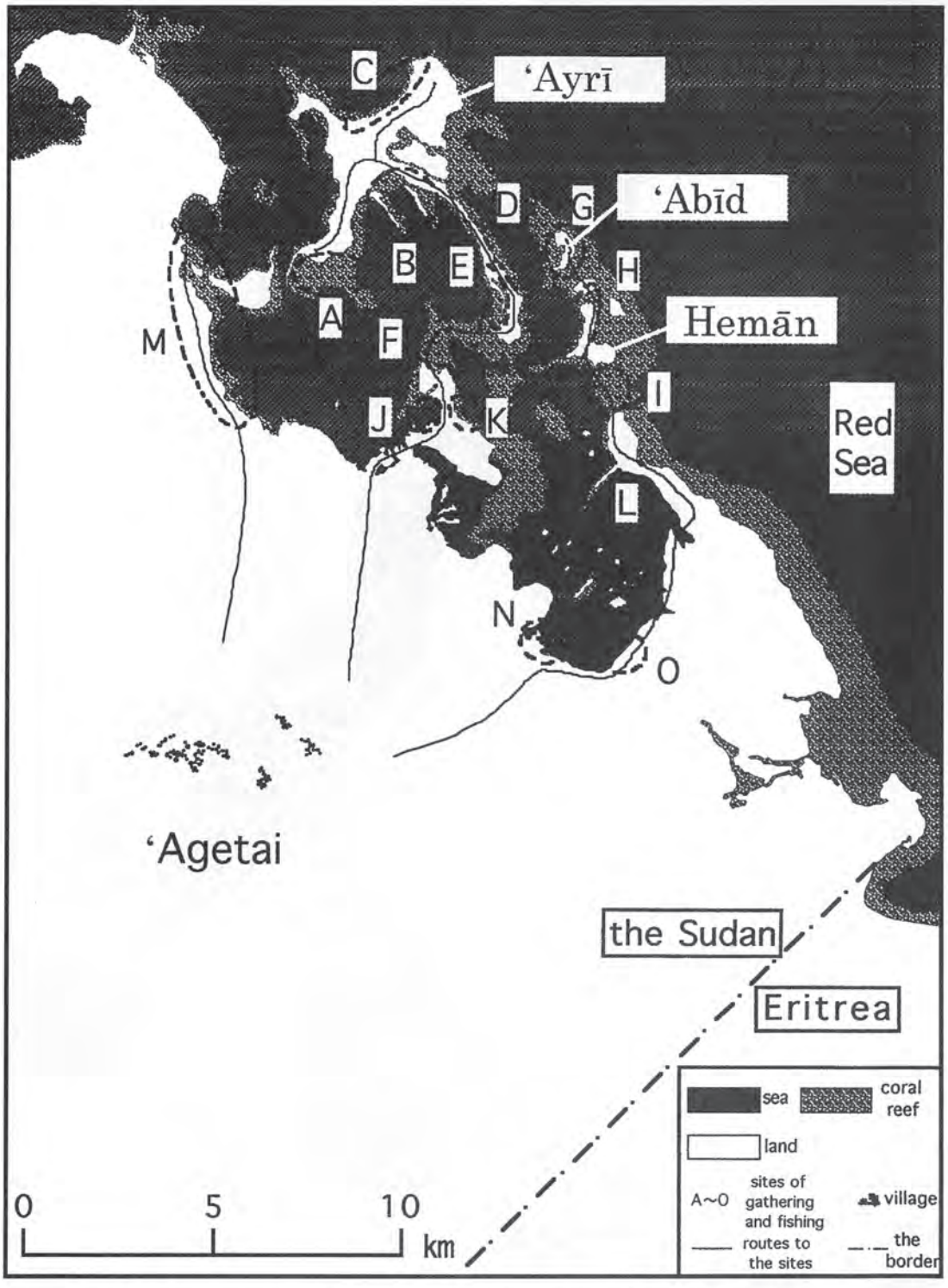
In spite such harsh circumstances in recent years, the Beja seem to have been surprisingly persistent in the same living areas for at least a thousand years. Accordingly, one of the main themes of research has been the understanding of traditional pastoral and agricultural subsistence economies (livestock production system and the land use system in particular). Even within a context of urbanization and modernization, most likely as a result of drought and famine, systematic analysis has been limited to agro-pastoral products as the dominant source of subsistence (Bakhit 1988; OXFAM 1990; Hjort & Dahl 1991; Morton 1993). Recent studies, however, show how the Beja are dependent on extra income generated outside the agro-pastoral system (production and sale of charcoal, *dum* palm tree mats and hides etc.), and pay attention to the totality of resources (Manger *et al.* 1996: 120–40). This case study may also shed a light on an overlooked aspect of subsistence activities among the Beja.

3. STUDY AREA

The Beja living area considered as a home range includes the Red Sea coastal region in eastern Sudan. The Red Sea region can be classified into three general physical units: the coastal plain, the Red Sea Hills, and the western plain. The Red Sea Hills, which represent the western edge of the Great African Rift Valley, extend for approximately 500 km in a northwest-southeast direction along the coast of the Red Sea. The altitude ranges between 900 and 1200 m above sea level. The western plain is located on the western side of the Red Sea Hills and the coastal plain on its eastern side. The coastal plain is a narrow strip ranging between 20 and 50 km in width, and extending from the shore to the foot of the Red Sea Hills (Hassan *et al.* 1996: 37–8, 205). The very small freshwater input from rivers or rainfall permits well-developed fringing reefs, which are found semi-continuously along both coasts of the Red Sea (IUCN 1988: xvii), and particularly in the Sudan the seaward



Map 1. Beja living areas and study location



Map 2. Gathering and fishing sites and access routes around 'Agetai village

edge of the fringing reef may be over 1 km from the shore, with a substantial 10 m deep lagoon in between. The Red Sea shores also contain sandy beaches, mudflats, and mangrove swamps (Head ed. 1987a: 9; 1987b, 131–2).

The survey area is around 'Agetai village on the coastal plain (Map 1)[4]. The village covers an area of about 3 km long by 5 km wide (Map 2). The estimated population is about 2000. Fieldwork was carried out during the period 1992–97[5].

Climatically the area exhibits a semi-arid subtropical Mediterranean type of climate in general (Bakhit 1988: 144). Annual rainfall means changed from over 400 mm in the late nineteenth century to less than 150 mm after the 1970s as a process of aridification intensified (Kassas 1957: 191; Abu Sin 1991: 9; Salah 1991: 2, 5). The mean temperature of the area is around 30° Celsius. Strong winds blow, especially during the summer season (Abdel Karim & Babiker 1991: 4–6). The vegetation is classified as the semi-desert grassland and shrubland that forms the eastern fringe of the Sahelian transition zone. Some data suggest that aridification has caused considerable ecological degradational changes in the vegetation. Thus, in fact, the present-day vegetation of this area seems to be the coastal desert that is said to cover the area north of Port Sudan. The coastal vegetation is characterized by drought-resistant halophytes (White 1983; Manger *et al.* 1996: 37–58).

The majority of the inhabitants of 'Agetai are the 'Ejīlāb clan of the Banī 'Āmir of the Beja. The Banī 'Āmir is less a tribe than a loosely knit confederation of groups of different origins (Paul 1954: 17–18). There are 'Ejīlāb, Aflanda and some other clans of the Banī 'Āmir in 'Agetai village. The 'Ejīlāb is thought to be ruling caste of Aflanda (Paul 1954: 83–4, 138). Other than the Banī 'Āmir of the Beja, the Rashāyda, who are immigrants from the Arabian peninsula (Young 1996), own small boats to fish in the Red Sea, and herd camels and other livestock. The Danākil (or Afar), who are immigrants from the so-called Afar Triangle in the Horn of Africa (Lewis 1955), engage in the same kind of work as the Rashāyda. All inhabitants are Muslims, and speak the Arabic language.

4. ACCESS TO GATHERING AND FISHING SITES BY CAMEL

4.1 The camel's usefulness in the littoral zone

I suggest that the camel plays a unique and significant role in the process of appropriating and carrying coastal resources, as a result of participant observation on gathering and fishing among the Beja (Photo 1). People make use of the camel as a supplementary means in these activities.

The one-humped camel (*Camelus dromedarius* L.) belongs to the family Camelidae of the order Artiodactyla. It is well known that the camel is excellent at moving on the loose sandy soils of the desert. One of the most striking anatomical feature of the camel is a structure of its foot. The front foot is about 19 cm long by 16 cm broad and covers an area of about 300 cm^2, which is twice as big as the human foot. The camel's foot splays out on taking the weight of the body, about 450–550 kg at maturity, and thus acts as a firm base for levering the weight forward to the next stride. The foot has been described as resembling a tire but filled with fat instead of air, because a fibrous rubbery sheath up to 10 mm thick covers the fatty pads. The camel, therefore, can move forward on deserts in which human and other animals would become stuck (Wilson 1984: 1–2, 65–6, 153–4).

Such well-adapted abilities are demonstrated on the bad terrain of both soft and hard substrates in the littoral and sublittoral zones (Photo 2). Both sandy beach and mudflat are periodically submerged and are very slippery. Then, the physical structure of the coral reef is irregular and complicated. But camels cope well with these various topographies. Other livestock (cattle, sheep, goat, and donkey) may fall into spaces between coral reef colonies, because their feet are smaller than camels', despite their weight being less. Although the donkey is used for riding and carrying water bags for short distances in land zones, it is not suitable for use in the littoral zone (Fig. 1). In sum, any other livestock than the camel will not serve to facilitate the human need to utilize the resources of both rocky and sediment shores in the littoral and sublittoral zones[6].

Photo 1. A view from a camel's back: camel silhouette with waves on a sandy beach, showing the clear contrast between the blue of the Red Sea and the white of the desert

Photo 2. Moving forward with a camel on slippery mudflats in the littoral zone

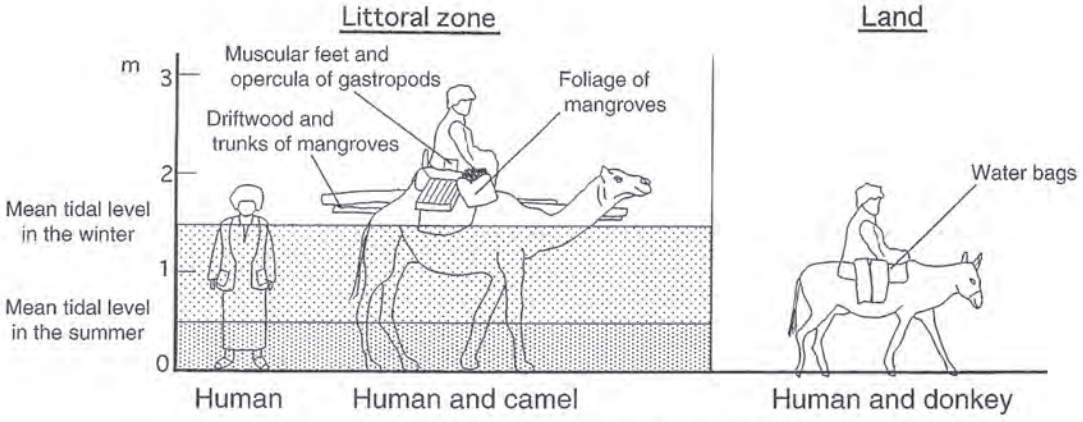


Fig. 1. The camel's ability in the littoral zone

4.2 Access to sites

Territorial rights and property rights in areas around 'Agetai village are claimed customarily and collectively by the inhabitants, with 'Ejīlāb as the majority[7]. Though members of other ethnic groups, the Rashāyda and the Danākil, can also use these resources it is only with permission from the 'Ejīlāb. I identify 15 sites, from A to O, of gathering and fishing activities under their management. Table 1 specifies the targets of resources site by site[8].

These sites of gathering and fishing activities exist on shores of both mainland and islands, including shallow-water reef tables. Normally sites can be approached only by foot, but are easily accessible by camel. Groups of people engage in the activities together (it is rarely a solitary pursuit).

The raised coral reef islands, such as 'Ayrī, 'Abīd, and Hemān, have heights of less than 10 m. It is possible to reach them without a boat by riding on a camel. For example, it is easy to cross to Hemān island, because the coral reef flat between the mainland and the

Site \ Activity / Target	Gathering		Fishing	
	Driftwood	Mangroves	Gastropods	Fish
A	–	○	○	○
B	–	○	○	○
C	○	–	–	○
D	○	–	–	○
E	–	–	○	–
F	–	–	○	–
G	○	–	○	○
H	○	–	○	○
I	–	–	○	–
J	–	○	–	○
K	–	○	○	–
L	–	–	–	○
M	–	○	○	○
N	–	○	○	○
O	–	○	–	○

Table 1. Targets of gathering and fishing activities by site

island is either exposed or below 1 m depth even at high tide. 'Abīd island, however, can be reached only on windless days at low tide, because of very fast water movement due to tides, wave action and currents, passing through constrictions between Hemān and 'Abīd islands[9].

The seasonal sea level regularly moves up and down throughout the year, being at its highest in winter and at its lowest in summer (Fishelson 1973: 184–6; Taylor & Reid 1984: 176). In winter the mean water level is nearly a meter higher than in summer in the central Red Sea (Abdel Karim & Babiker 1991: 4). The mechanism causing the seasonal tide is driven partly by greater evaporation in the summer, but is mainly the result of wind-driven currents in the entrance to the Red Sea. The surface current in the Bab el Mandeb flows into the Red Sea in the winter, while in the summer strong winds blow the surface part of this outward, and this appears to be the main factor in determining the seasonal rise and fall (Sheppard *et al.* 1992: 52–3).

The upper parts of the reef flats between the mainland and 'Ayrī island are found 0.5 to 1.5 m below mean-water level. The deepest part has an approximate depth of 2 m in the winter season. The platform of coral reef flats provides an occasional corridor between the mainland and this island, and it takes about one hour to cross the distance of 2 km. Therefore, camel teams start to cross early in the morning, the time when the sea wind stops and before the tide comes in. The water goes up almost to the shoulder of the camel (Fig. 1)[10]. However, they are sturdy and brave enough to walk on the narrow ridge of coral reefs, a stony path where it is hard for them to retain their footing (Photo 3). The camel pastoralists accurately assess whether they can cross the sea under prevailing circumstances.

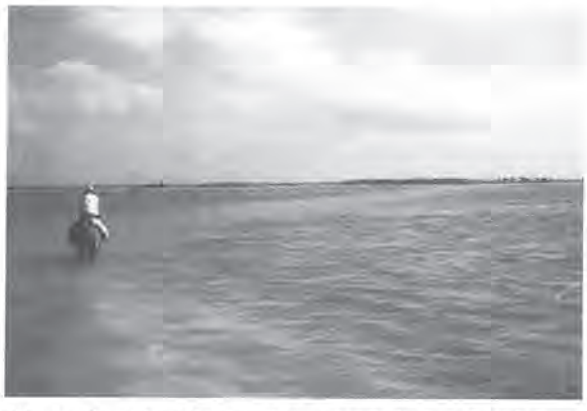


Photo 3. Heading for 'Ayrī island with a camel, crossing the distance of 2 km on coral reef flats

Photo 4. Loading driftwood and a wooden box on a camel, and bringing them to the village

Photo 5. Piling up driftwood and raising a calf for a marriage gift

It also needs to be noted that the activities on coastal areas are exclusively a male task. Females do not participate in gathering and fishing, even though their village is located just 5 km from the shore. The camel riders are mainly young males, whose age is between teenage and thirties. I heard that almost none of them could swim adequately.

There is a life-passage reason why young males take part in these activities, related to the time when they become independent of their parents. They learn to manage a riding camel in later teenage, before which they must work with adult males, except for herding flock of sheep and goats, which they can do by themselves.

Gathering and fishing trips allow them to be away from their village for one week until their drinking water runs out. The young males, who know each other well, chat about all kinds of things, not only on their camel's back in daytime, but also around the fire at night. They may sometimes joke and make fun of each other, and sometimes argue and quarrel seriously. Talk about girls is a frequent topic. Heading for coastal areas, then, is a kind of passage of independence at an age between boyhood and youth.

5. DRIFTWOOD

Arriving at the islands, the young males run and try to get first to the beaches, because priority and ownership go to the one who finds driftwood. There is a good possibility of finding it, especially after strong sea winds.

Driftwood, in this case, does not mean natural wood but processed wood, as used for palettes or packing cargo. Shapes can be long, reaching a few meters, or heavy boxes nailed up together, or even a neat wooden box (Photo 4). However, these can be found only on islands facing the sea (such as sites C, D, G, H). The young males put this material on a camel's back and return to their village, piling up or standing the boxes against a wall of their house (Photo 5).

The boxes can be used as materials for building settlements, and for new houses after marriage in particular. In urban centers such as Port Sudan and Suakin, cargo wood is traded and used secondly for building materials. A rectangular parallelepiped house made of such wood is called *beit sandaqa*. In 'Agetai, this type of house is popular among people who have some relationship with urban areas, such as an owner of a shop selling daily necessities. In *beit hashīsh*, a more traditional type of house is made from the trunk of a mangrove as the chief pillar, strengthened by driftwood.

6. MANGROVES

Mangroves (mangrove plants) are the constituent plants of tropical intertidal forest communities (Tomlinson 1986: 3). At the survey area, I found only one species, *Avicennia marina* (Forsk.) Vierh. (vernacular name: *shāwara'*)[11]. A eurythermal and euryhaline mangrove species, *Avicennia marina* has the ability to adjust to low winter temperatures and

Photo 6. Cutting down young foliage of mangrove, and feeding a camel

high salinity, and is dominant in the Red Sea (Tomlinson 1986: 199–202; Sheppard *et al.* 1992: 162–3, 173, 255).

The outer wall of a *beit hashīsh* house is made of a combination of *Calotropis procera* (Ait.) R. Br. (vernacular name: *genṭe*) and the trunk of *Avicennia marina*, with a final coat of paint with cattle excrement. Most houses in 'Agetai are of this type.

When cutting down mangrove trees, builders are careful to leave a stump of several tens of centimeters above the surface. A principal aim of their activities is the systematic preparation of a new house for the time of marriage. Simple shades made of these building materials are also erected at some of the gathering and fishing sites.

As far as I could observe, there is no longer large-scale cutting of trunks for firewood and charcoal. Only dead branches are used for fuel, with camel excrement, while men are engaged in gathering and fishing along the coast. Fuel in everyday life at the village consists of dead herbage such as *Panicum turgidum* Forsk. (vernacular name: *sarra'*).

The most important aim of mangrove use is to collect branches and foliage for camel forage. The evergreen foliage of *Avicennia marina* contains less tannin than other mangroves, and is suitable for camels (Chapman 1976: 378). It is known that a mangrove community located in less than 2 m of water is invariably browsed by camels all year round[12]. In addition to this use, evergreen foliage is cut by humans and used for forage (such as at sites A, B, J, K, M, N, O). This helps in maintaining a regular supply of forage for the camels.

People go into the mangrove stands, which cannot be approached by camels alone because of poor footing. They cut down mainly young foliage with an ax, then pack it into hemp bags and carry it to the shore (Photo 6). Some is given to camels that come to the shore, and the balance is loaded on camel back and brought for other pack/riding camels. The amount of foliage gathered in an hour will be the amount of main (not supplementary) feeding for one pack/riding camel for one week.

7. GASTROPODS

The coastal communities of mangals, seagrass beds, and coral reefs are highly interdependent (Head 1987a: 9–10). Seagrass beds hold an ecological significance as primary producers in coastal environments (Sheppard *et al.* 1992: 143) and coral reefs provide shelter for many fishes as well as various species of polychaetes, crustaceans, molluscs, and echinoderms (Loya 1972: 100).

The third target of the gatherers' activities is gastropods. There are two species: Three-knobbed conch, *Strombus (Tricornis) tricornis* (Lightfoot, 1786) and Virgin murex, *Chicoreus virgineus* (Roding, 1798). I observed that the murex is comparatively numerous on the seaward fringe of coral reef flats facing the open sea (such as sites F and I), while the stromb occurs at the landward edge of the coral reef flat adjoining the lagoon (such as sites A, B, E, K, M, N)[13]. Gathering areas at sites are located in the sublittoral zone of shallow waters that are not deep enough to approach by boat, but not close enough to reach by foot. The best way for gathering the maximum harvest of gastropods is to ride on camels and go to the coral reef flats.

The principal reasons why gastropods are prized are to use the muscular feet as bait for fishing; to eat the feet as food; and to obtain opercula for incense and perfume.

7.1 As bait for fishing

At site A, three men can collect approximately 20 gastropods within half an hour (Photo 7). Then they smash the shells by ax on a piece of mangrove root. They take out the flesh from inside and remove opercula out of the flesh. After that they put the flesh on a hook at the end of nylon handline, which is rolled up around a piece of wood.

To fish they go on foot about 40–50 m offshore, where the water reaches above their waist. Two of them drop a handline with hook and bait. Stretching their arms, and sometimes bringing up a line, they wait for a fish to bite. When they catch a fish, they take it from the hook and hand it to another man (Photo 8). He puts his fingers into its gill, and breaks the backbone to kill it. After that he removes the scales from the fish. An internal organ of the fish is used as bait for the next fish. Within one hour they often capture 10 fish. Dory snapper, *Lutjanus fulviflamma* (Forsskål, 1775) (vernacular name: *maharūb*), Yellowfin bream, *Rhabdosargus sarba* (Forsskål, 1775) (vernacular name: *sho'ūla*), and Red Sea houndfish, *Tylosurus choram* (Rüpell, 1837) (vernacular name: *shunbrūr*) are the species most frequently caught[14].

After bringing these reef-associated fishes to land, the men make a fire of dead branches of mangrove with camel excrement. They chop onions into fine pieces, and fry these with oil in a pan on the fire. They hack up the fish into pieces with an ax using some mangrove roots as a chopping block, and put these pieces into the pan and boil with salt. When the fish taste penetrates into the soup, the pan will be removed from the fire.

At the same time, they knead dough that they bring from their village, and roll it out dough into a circle about 20 cm across. A kind of bread can be baked in the ashes. After tasting a cup of fish soup, they soak the bread in the soup and eat it with pieces of fish. They drink a cup of coffee with ginger or cloves at the end of the meal.

This meal on the coastal areas is different from the ordinary meals in a village (*asīda*: a kneaded and hardened lump made of sorghum or millet powder mixed with cow milk). Coral reef fish provides the main food resource for men engaging in activities on the coast.

Fishing time is typically either between sunrise and noon or between evening and night. Fishing lines and hooks are also left out overnight, and I observed once that the men caught a kind of manta 1 m long and released it without eating.

7.2 As food

The muscular feet of gastropods, both *Chicoreus virgineus* and *Strombus tricornis*, are consumed as animal protein for the diet[15]. The men put the shells on a fire, and pull out the grilled flesh with a knife or twig (Photo 9). This method of eating, though, is practiced only in the winter season.

As described earlier, the sea level is higher in the winter, and it is difficult to cross to the island and collect gastropods in abundance. In the summer, it is very windy, hot and humid. A strong wind blows up and the temperature goes as high as 45° Celsius. Yet, despite such conditions, more people go to camp on the shore and collect gastropods

Photo 7. Young male collecting gastropods on fringing reef flat, and shells left on the shore

Photo 8. Catching fish with hook and line, using gastropod feet as bait

Photo 9. Putting shells of gastropods on a fire, and eating the fleshy feet

Photo 10. Sun-dried gastropod flesh as preserved food

during summer than in winter.

In summer drying out the gastropods takes about one hour under the hot sunshine on a sandy beach. Operculum is removed, washed with seawater, and left again in the sun. People bring this sun-dried gastropod flesh to their village and keep it as preserved food for all members of their families (Photo 10).

7.3 As incense and perfume

The operculum is used for incense and perfume (Photo 11)[16]. The operculum of gastropods of molluscs is a horny or calcareous structure attached to the foot (Abbott & Dance 1982: 2).

One man, for example, took one *ukīya* (approximately 40 g) of opercula within a week in June, usually the peak period[17]. Most opercula are from *Strombus tricornis* (Photo 12).

Opercula is brought back to 'Agetai village, then village merchants go to urban centers in the coastal plain, such as Port Sudan and Suakin, to sell this produce. In the summer, when many opercula are harvested, outsiders come to the village to purchase them from the villagers. These are often merchants of the Beja or Takarīr, West African immigrants, from Port Sudan or Suakin. They bring opercula to Port Sudan and Suakin on the Red Sea coast, then to inland cities such as Kassala and Khartoum where Sudanese merchants or Indian merchants, Hunūd, distribute to other parts of the Sudan and also outside the country.

Prices in Kassala and Khartoum are twice as much as those in 'Agetai village[18]. Income from opercula is the only cash resource for the villagers other than selling their livestock.

I researched the kinds and prices of opercula in Port Sudan, Suakin, and Khartoum. I saw six kinds of opercula, and identified two of them as the same kinds as found around 'Agetai village. Based on an interview with some fishermen in Suakin, I ascertained that

Photo 11. Removing opercula from flesh of gastropods

Photo 12. Muscular feet at right and opercula at left

Species of gastropod			*Strombus tricornis*	*Lambis truncata sebae*	*Chicoreus ramosus*	*Chicoreus virgineus*
Shell	Morphological feature					
		Length (cm)	8.0 ~ 12.0	27.0	13.0 ~ 17.0	8.0 ~ 10.0
		Width (cm)	6.0 ~ 11.5	17.0	9.5 ~ 13.0	5.0 ~ 6.5
	Vernacular name	in Arabic in Tigre	ḥajar zurūmbāk ge'māi nūsh	ḥajar zurūmbāk ge'māi 'abi	ḥajar zurūmbāk ḥajar ghirjummatt	
	Price*		As ashtrays, omamental objects and souvenirs: 100-300 £ S at Suakin			
Muscular foot	Vernacular name	in Arabic in Tigre	zurūmbāk alha'		zurūmbāk ghirjummatt	
	Price*		Sun-dried flesh of four species of gastropods (mainly conch): 1,400 £ S/kg at Suakin			
Operculum	Morphological feature					
		Long diameter (cm)	2.0 ~ 4.5	4.0 ~ 6.5	3.0 ~ 5.5	1.7 ~ 4.4
		Short diameter (cm)	0.5 ~ 1.0	1.5 ~ 2.0	1.7 ~ 3.1	1.2 ~ 3.1
		Thickness (cm)	0.05 ~ 0.1	0.1 ~ 0.3	0.25 ~ 0.5	0.1 ~ 0.3
	Vernacular name	in Arabic	ḍufra ḍufra saghīra ḍufra dankal rīsh	ḍufra ḍufra kabīra	ḍufra ḍufra dā'ira	
		in Tigre in Beja	echlāf nāf	echlāf nāf	ḍufra arfūb	
	Number of items	Per ukīya**	Approximately 400	Approximately 40	Approximately 25***	
	Price*	Per ukīya** at Port Sudan	4,000	3,000	2,000	

* 1 US $ equals 500 £S. Prices at March 1995
** I ukīya equals approximately 40 g
*** opercula of both *Chicoreus virgineus* and *Chicoreus ramosus* are mixed together (approximately 50:50) for sale

Table 2. Morphological features, vernacular names and prices for parts of a gastropod: shell, muscular foot, and operculum

Seba's spider conch, *Lambis (Lambis) truncata sebae* (Kiener, 1843), and Ramose murex, *Chicoreus ramosus* (Linné, 1758), are mainly caught by fishermen who engage in net fishing around islands a little way from the shore[19]. These four kinds are found in the Red Sea, but the other two are not from the Red Sea[20].

Perfumes are plentiful in the Sudan, including Beja living areas, and include incense, perfume ointment, and perfume oil[21]. These perfumes, a part of distinctive Sudanese culture, require opercula as a raw material. Opercula of *Strombus tricornis* are especially highly prized. Perfumes are made by women, and cannot be excluded from items of bridewealth from groom to bride for marriage. They have particular significance for the first night but also for the rest of married life. Table 2 shows the vernacular names and features of each usable part of the gastropods, and compares prices in detail.

I made an ethnographical observation on usage of opercula as incense and perfume by women, one at Port Sudan in eastern Sudan and another at Khartoum in central Sudan. There are differences in processing procedure, although two women emphasized the

Photo 13. Removing sticky things from opercula that give off a foul smell

Photo 14. After being stir-fried on a pan, opercula must be ground into powder

Photo 15. Incense, perfume oil, and perfume ointment include opercula of gastropods as a raw material

process of removing sticky things (seemingly a part of the muscular foot) that give off a bad smell.

They leave approximately one *ukīya* of opercula in hot water for a while in the sun, and removed the sticky parts directly one by one (Photo 13). These are stir-fried and mixed with sand, until the colors on the edges of the opercula change. The reason for using sand is to remove a foul smell and not to burn the opercula. Opercula are ground together into powders traditionally in a iron bowl with a stick, and in modern times with an electric mixer.

In another method, opercula are boiled with sorghum and washed with a piece of soap. This way seems to get rid of the smelly parts more readily. The opercula are dried for half a day, and stir-fried directly on a pan over a charcoal fire (Photo 14). Opercula, clove, misk, and *mahlab* (*Prunus mahaleb* Mill.) are ground together into powder, mixed with water and added to incense, perfume ointment, and perfume oil (Photo 15). Nonetheless, the smell of opercula, even after being stir-fried and ground, still seems fishy to me.

8. DISCUSSION

The goals of gathering and fishing activities with camels among the Beja are to find driftwood (processed woods); trunks, dead branches, and foliage of mangroves (*Avicennia marina*); the muscular feet and opercula of gastropods (*Strombus tricornis* and *Chicoreus virgineus*); and fish (*Lutjanus fulviflamma*, *Rhabdosargus sarba*, and *Tylosurus choram*, etc.).

The objectives of these activities, as drawn from this research, are:

- to find driftwood for use as building materials;
- to cut down trunks of mangroves for use as building materials;
- to collect dead branches for use as a fuel;
- to cut down foliage of mangroves for use as camel forage;
- to capture fish by using flesh of gastropods as bait for handline fishing;
- to collect gastropods to eat the flesh;
- to obtain opercula of gastropods for use as incense and perfume.

Overall livestock productivity is difficult to establish in a precise and quantitative manner. Meat and milk production is not the first and foremost goal and output of African pastoralists. There are many others, such as dung and manure, draught power, transport, hides and skins, wool, hair, etc. Although transport and draught power are important factors in the daily life of pastoralists, these are often overlooked by researchers, with the exception of a few studies (Wilson 1984: 164–70; Le Houérou 1989: 135–9).

Measuring and analyzing the energy-flow system in Nuñoa, the altiplano region of southern Peru, Thomas (1976) illustrated energetically that the llama reduces human energy expenditure-related transport, and its value lies in its multiple utility as a pack animal and as a secondary wool and meat source.

It is well known that the camel has been used for multiple purposes throughout history: riding, pack/baggage, water-lifting, milling, and cultivation, in addition to milk, meat and hide production (Bulliet 1975; Wilson 1984). However, the ecology of the highly topographically complex shores of the Red Sea, particularly the physical nature of fringing reef flats and shallow reef tops, demonstrates a hitherto unknown utilization of the camel. This paper reveals the invaluable specialized function of the camel for the exploitation of coastal resources.

People can access sites of gathering and fishing activities easily, by riding on a camel, which is capable of walking on flats of sand, mud or coral reef. Further, camels can carry very heavy and bulky loads. Pastoralists can enlarge the usable range of these activities even to islands without boats and exploit available resources in response to daily, monthly, and yearly cycles of tidal conditions. Thus, I suggest that the value of camels in coastal areas cannot be understood solely in terms of the pastoral production system: converting the energy in plant products that humans cannot eat into food energy available for humans as milk and meat.

Figure 2 is an attempt, based on this field data, to classify the principal types and purposes of resource use by gathering and fishing activities in the Sudanese Red Sea coastal area. The camel gives pastoralists access to different types of resources: as food (animal protein for the diet); as a means of subsistence (vegetable forage for livestock; bait for fishing); and as daily life materials (building materials; fuel; incense and perfume). Providing a direct source of food for humans is only an aspect of the important attributes of the camel in coastal environments. This fact illustrates the multiple dimensions of camel utilization.

If we look at the Beja subsistence system as a whole, the value of gathering and fishing activities on coastal areas would not be higher than that of the pastoral economy[22]. At the same time, however, it would seem that its supplementary role should not be taken lightly,

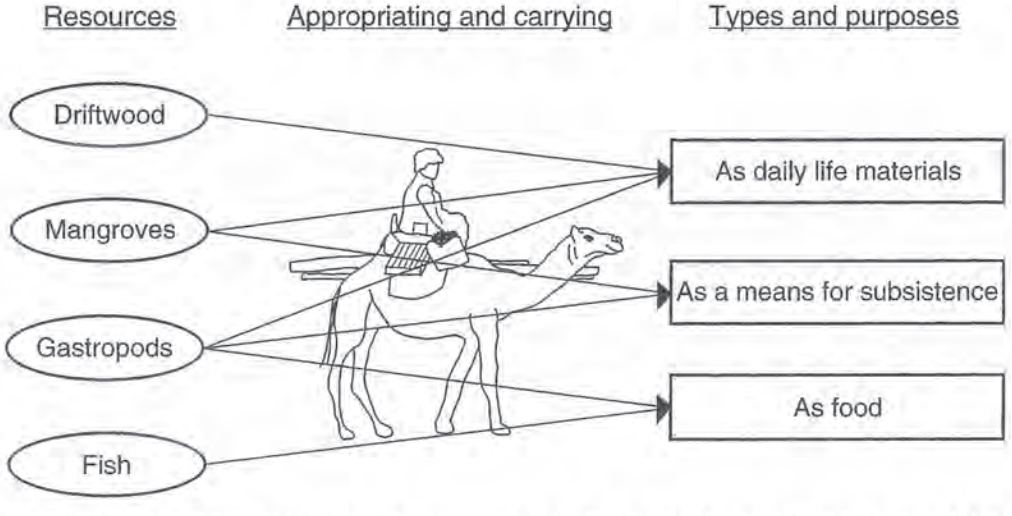


Fig. 2. Principal types and purposes of resource use by gathering and fishing activities on the Sudanese Red Sea coastal area

Photo 16. We should reconsider subsistence economies of camel pastoralists who have survived in arid lands, focusing on resource use on the coast

because of uncertainty in pastoral productivity, with a high degree of unpredictability of rainfall in time and space.

Further, it is necessary to place the importance of gathering and fishing activities on the coastal area within the dynamic between food-collecting and non-food-collecting purposes. Especially, we should not overlook the use of opercula as incense and perfume in the sense that these have been traded in broader networks[23], and provide cash income to a people who are suffering from hunger under recent drought conditions. To conclude, this field research among the Beja on the Red Sea coast presents a new perspective on aspects of the subsistence economy of camel pastoralists who have survived in arid lands, focusing on resource uses on the coast. Gathering and fishing activities have to be taken into account in understanding the totality of subsistence economies among the Beja (Photo 16). I will continue to examine the relationship between certain features of the natural environment and certain traits of human adaptation that directly depend on that specific environment, and investigate the adaptive strategies and survival mechanisms among pastoral societies from diversified points of view[24].

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NOTES

(1) I use the term "camel pastoralists" to refer to people who are not exclusively but principally dependent for their subsistence on pastoral products, and have a higher degree of dependence on the camel than any other livestock in terms of both productivity and social/cultural values. The Sudan has the second largest number of camels in the world and almost 1.5 million km² of territory suitable primarily or solely for their use (Wilson 1984: 39–41).

(2) In general, the term "gathering" refers to human foraging activities as a mode of production: to collect plants, shellfish, insects, eggs or small animals as food resources. Here, I extend this usage to non-food-collecting activities.

(3) "Beja" has been a term used largely by outsiders, and is not necessarily the most important ethnic category for the Beja themselves (Morton 1993: 32). According to Jacobsen, the term "Beja" is a non-native term not used by Beja themselves, who will usually refer to themselves as Bedawiét. The Beja do not at present exist as a political entity and are perhaps better labeled as

a linguistic unit, as speakers of the Tu Bedawie language (Jacobsen 1998: 5, 23).

(4) This area is situated about 210 km southeast of Port Sudan; 30 km eastsoutheast of Aqiq in South Tokar District; 20 km from the Sudan-Eritrea border (18° 19' 95" N, 38° 4' 4" E).

(5) Data on gathering and fishing activities were collected particularly at the following periods: February 1994; June 1994; February 1996; data on perfume and incense processing: March 1995. I identified species using the following reference books: *mangroves*: Kassas 1957; Chapman 1976; Babiker 1984; Tomlinson 1986; *gastropods*: Vokes 1964, 1971; Radwin & D'Attilio 1976; Abbott 1960, 1961; Mastaller 1979, 1987; Abbott & Dance 1982; Dance 1992; *fish*: Reed 1964; Randall 1983; Dor 1984; Ormond & Edwards 1987.

(6) According to Wilson (1984: 66), the camel's foot is less suitable for traversing stony desert although some hardening occurs in animals habituated to this kind of terrain. It is equally unsuitable, in principle, for travel on slippery or muddy surfaces but some camels become adept at traversing even this kind of terrain.

(7) In general, the Beja are divided into five groups: 'Abābda, Bishārīn, 'Amarar, Hadanduwa, and Banī 'Āmir. Among Hadanduwa, their minimal lineage group is called *diwāb*. The *diwāb* is the corporate group proper by which one, through shared descent, is entitled to share rights to a piece of land and all its productive resources. The main efforts of Hadanduwa in socio-economic terms are directed toward their own *diwāb* (Jacobsen 1998: 25). Hadanduwa are patrilineal with uxorilocal residence, and no social relations can be explained solely by unilineal descent. All social relations can therefore be said to have been molded equally by descent and residence ties (Hassan 1987: 18). Ideally, each tribal and subtribal group is affiliated with a piece of land in such a way that one's closest neighbors tend to be one's closest relatives from the perspective of patrilineal descent. However, the most important herding and land-using group, the lower-level *diwāb*, is ambilineal in its recruitment. This is the only effective corporate group claiming customary rights to a grazing territory (Jacobsen 1998: 24). In this sense, the 'Ejīlāb clan of the Banī 'Āmir of the Beja seems to share this socio-economic system, too.

(8) Here I use the term "site" to mean a walking range of subsistence activities, including the point at which people unload to camp or rest for a while.

(9) I heard that in the 1970s a man tried to cross to 'Abīd island for gathering and fishing activities, but he was washed away by strong currents with his camel. His corpse drifted ashore on 'Ayrī island.

(10) The camel is as tall as 2.00 m at the shoulder in this area.

(11) *Rhizophora mucronata* Poir and *Bruguiera gymnorhiza* (L.) Lam., along with *Avicennia marina*, are also reported on the Sudanese Red Sea coasts south of Suakin in which the research area is included (Anders 1950: 211). Some people of the village recognize another kind of mangrove that is excellent for building material. I myself observed something that looked like viviparous seedlings floating on the surface of the seawater, though I could not identify the species.

(12) The leaves and shoots of *Avicennia marina* are invariably browsed by camel (Kassas 1957: 196; Manger *et al.* 1996: 66). Babiker (1984) classified mangrove vegetation in the Red Sea shores of the Sudan, according to the particulars of the habitat, degree of compactness of aggregation, and the morphological behavior of its individuals. He pointed out that one of the main elements of disturbance is the accessibility of the camel. Hjort & Dahl reported that the shallageea type of camel among the Atmaan Beja is also very skillful at walking into the sea and browsing the leaves and fruits of mangrove (Hjort & Dahl 1991: 137).

(13) The typical habitat of *Strombus tricornis* is the vast seagrass beds formed by the spermatophytes *Halodule* and *Halphila* (Mastaller 1987: 204). *Strombus tricornis*, a browsing herbivore, grazes upon a variety of algae, with *Sphacelaria* a major item, but also *Ulva*, *Enteromorpha*, *Caulerpa*, and *Polysiphonia*, as well as blue-greens (Taylor & Reid 1984: 188). Although the detailed feeding behavior of *Chicoreus virgineus* is not known, most of the mureicid gastropods are predators (Taylor & Reid 1984: 190–2).

(14) *Lutjanus fulviflamma* is common throughout the year and usually found around the inner edge of the fringing reefs (Reed 1964: 3). It shelters near overhangs or in gullies near the reef crest, often where there is some surf, and wave surge (Ormond & Edwards 1987: 266). For snappers (Lutjanidae), migratory feeding on an alternating basis is common between coral reefs and seagrass beds. Mangroves also provide a nursery or feeding ground and protection for snappers

(Sheppard *et al.* 1992: 155, 168). *Rhabdosargus sarba* is also a predator of medium-sized invertebrates, principally crustacea and molluscs, which it crushes with molar-like teeth. It inhabits the shallow channel inside the fringing reef and most of the *marsas* along the coast (Reed 1964: 86; Ormond & Edwards 1987: 267). The fringing reefs of the Red Sea are penetrated at intervals by narrow channels, called *marsas*. These are interpreted as drowned river valleys cut during the Pleistocene (Berry *et al.* 1966), and they generally connect to wadis or seasonal rivers (Head 1987b: 133). *Tylosurus choram* is the surface-swimming species that can be seen in the fringing reefs and *marsas* (Reed 1964: 21). See Roberts & Ormond 1987 for habitat complexity and coral reef fish diversity and abundance on the Red Sea fringing reef.

(15) It has been already known that *Strombus tricornis*, *Lambis truncata sebae* and *Chicoreus ramosus* are collected for drying the flesh (Mastaller 1978: 125; 1987: 198).

(16) Opercula have been used as incense and perfume historically not only in the Sudan but also in many areas in the Middle East and India (Nawata 1997). The Japanese scholar of incense and perfume history, Kentaro Yamada, examined mixed incenses and perfumes from Chinese and Japanese historical sources, and concluded that "opercula are added in order to make odor fixed, mixed, harmonized, and stabilized" (Yamada 1976: 175–6, 211).

(17) Schroeder (1981: 254) reported that one pound of opercula may contain 1000–2000 pieces, and sales in the Port Sudan market average 13 pounds per day. Further, most probably based on the above-mentioned report, average sales in the Sudan markets were estimated at the production of perhaps 18,000 shells per day (Sheppard *et al.* 1992: 281). But this number seems an overestimate to me.

(18) It cost about 14,000 Sudanese pounds in 'Agetai; 17,000–18,000 in Suakin and Port Sudan; 25,000 in Kassala and Khartoum for 1 raṭl, about 450 g, of opercula of *Strombus tricornis* in March 1995.

(19) Although only *Strombus tricornis* is thought to be the source for opercula (Mastaller 1987: 198), *Lambis truncata sebae* and *Chicoreus ramosus* are collected only for food (Mastaller 1978: 125). This field research would be the first observation indicating that opercula of *Chicoreus virgineus*, *Lambis truncata sebae* and *Chicoreus ramosus* are also obtained.

(20) One is called *ḍufra khalījīya* (operculum of the Gulf), and another is *ḍufra hindīya* (operculum of India). Although it is thought that most opercula are imported from the Gulf countries or from India (Schroeder 1981: 254) or that some of the gastropods are imported, there is some local collecting (IUCN 1988: 335). These two kinds are circulated very little in the Sudan, as far as I could establish. The merchants told me that these were imported a few years ago when Sudanese opercula were not in abundance. It remains an unresolved question from which gastropods of molluscs these two kinds of opercula are obtained. Informants also told me of opercula of *Strombus tricornis* not only from the Sudan, but also from the coast of Eritrea and Yemen facing the Red Sea.

(21) Some ethnographers have reported on types and usage of Beja and other Sudanese perfumes (Keimer 1953; Kennedy 1978; Cloudsley 1983; Boddy 1989; Hjort & Dahl 1991; Kenyon 1991). It differs slightly depending on area, but many types seem to be shared in the Sudan.

(22) In this paper, I do not specify to what degree the pastoralists of the Beja depend on marine products and to what degree their camels depend on mangrove foliage as forage in terms of nutritional value. Therefore, in terms of total values of the use of coastal resources in subsistence economies, many issues remain to be analyzed further. I recognize that more research needs to be done on a local community's relationships to resource management. I also intend to move in future from descriptive methods and qualitative observation to quantitative analysis in order to measure the impacts of human exploitation on shore communities.

(23) It is known that, according to Arabic sources, operculum as incense and perfume was exported from Bāḍi', which is located on the southern tip of the starfish-shaped area of 'Ayrī island, in the eighth century (Nawata 1997). Bāḍi' had been the port connecting sea networks and the interior of Ethiopia and the Sudan in the period from the 7th to the 11th century (Kawatoko 1993a, b).

(24) I am preparing further papers concerning grazing lands and watering places in order to illustrate the camel's adaptation to a coastal environment. The camel favors salt-tolerant plants of coastal vegetation, and is able to drink well water containing high salinity caused by seawater

intrusion. The coastal area is a suitable habitat for the camel morphologically, behaviorally and physiologically. I will demonstrate that one of the most striking features of the adaptive strategies of the camel pastoralists living on the coastal areas is that pastoral activities are strongly connected with gathering and fishing activities as represented in this paper.

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