Tamuniyah, January to June 2000

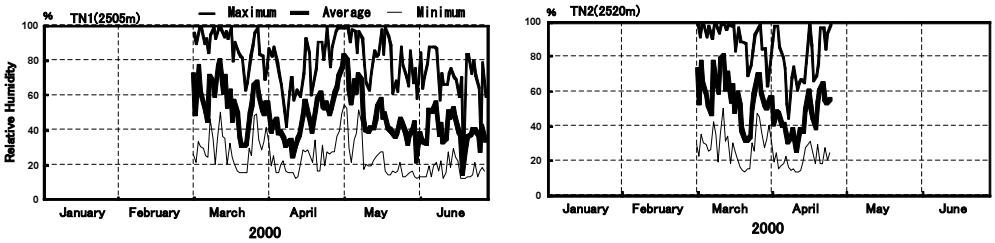


Fig. 1-35. Daily maximum, daily average, and daily minimum relative humidity in Tamniyah from January to June 2000

Jabal Tallan, January to June 2000

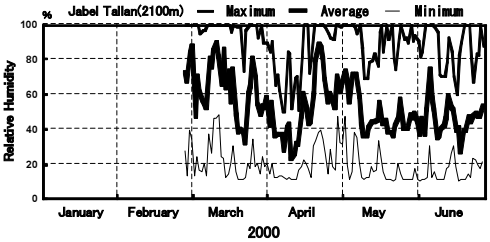


Fig. 1-36. Daily maximum, daily average, and daily minimum relative humidity in Jabal Tallan from January to June 2000

Tamuniyah, July to December 2000

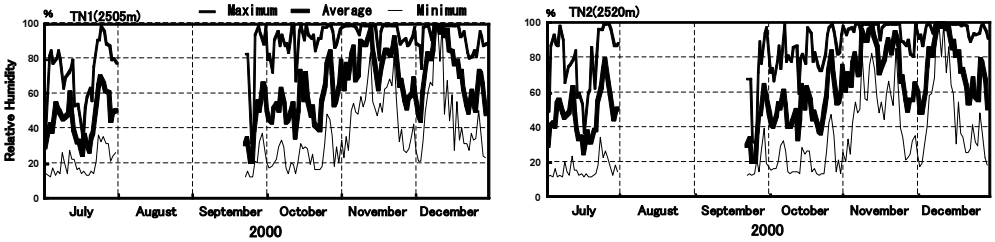


Fig. 1-37. Daily maximum, daily average, and daily minimum relative humidity in Tamniyah from July to December 2000

Jabal Tallan, July to December 2000

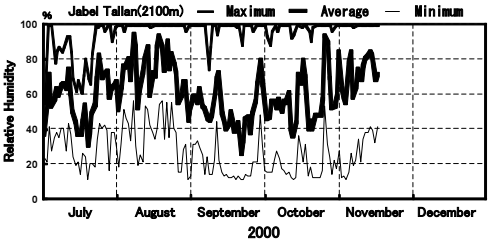


Fig. 1-38. Daily maximum, daily average, and daily minimum relative humidity in Jabal Tallan from July to December 2000

Tamuniyah, January to June 2001

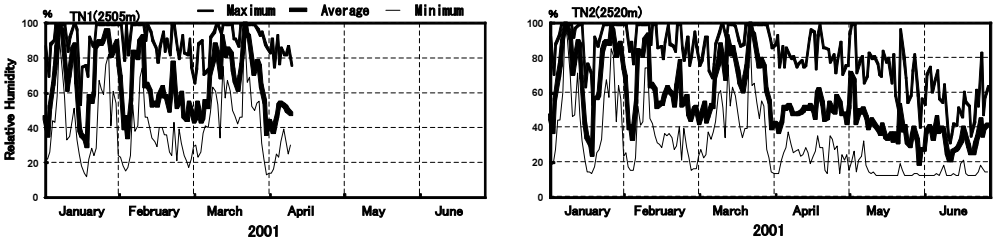


Fig. 1-39. Daily maximum, daily average, and daily minimum relative humidity in Tamniyah from January to June 2001

Jabal Tallan, January to June 2001

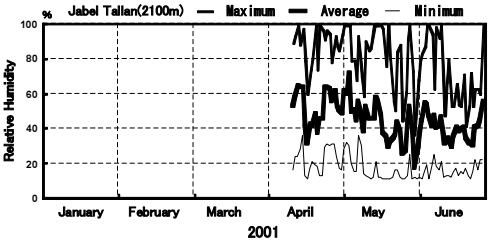


Fig. 1-40. Daily maximum, daily average, and daily minimum relative humidity in Jabal Tallan from January to June 2001

Tamuniyah, July to August 2001

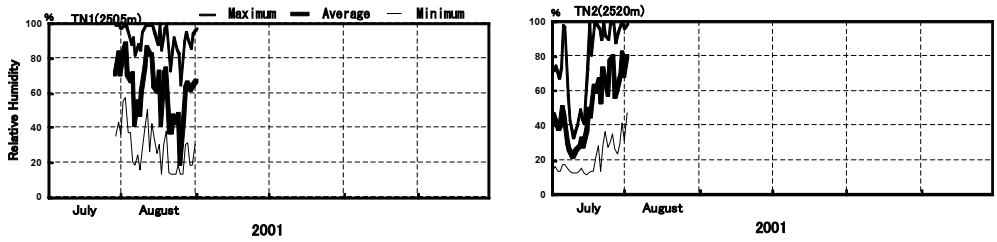


Fig. 1-41. Daily maximum, daily average, and daily minimum relative humidity in Tamniyah from July to August 2001

Jabal Tallan, July to August 2001

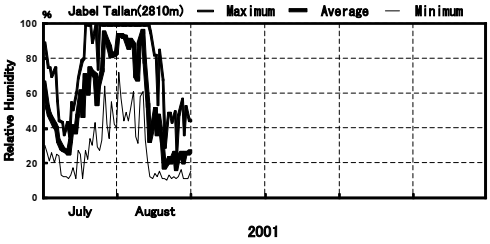


Fig. 1-42. Daily maximum, daily average, and daily minimum relative humidity in Jabal Tallan from July to August 2001

July to December 1999

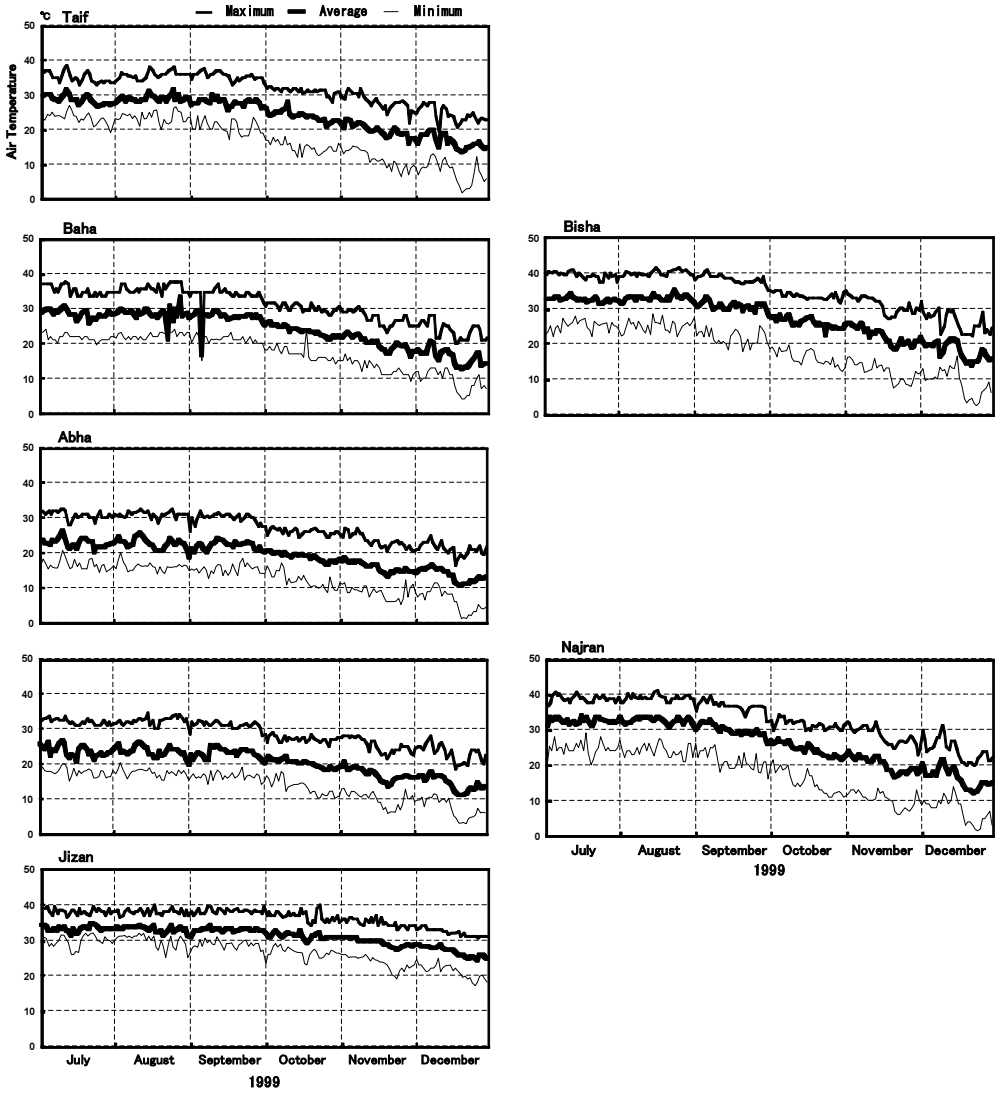


Fig. 1-43. Daily maximum, daily average, and daily minimum air temperature in seven cities around the Asir Mountains from July to December 1999 (from data of MEPA)

January to June 2000

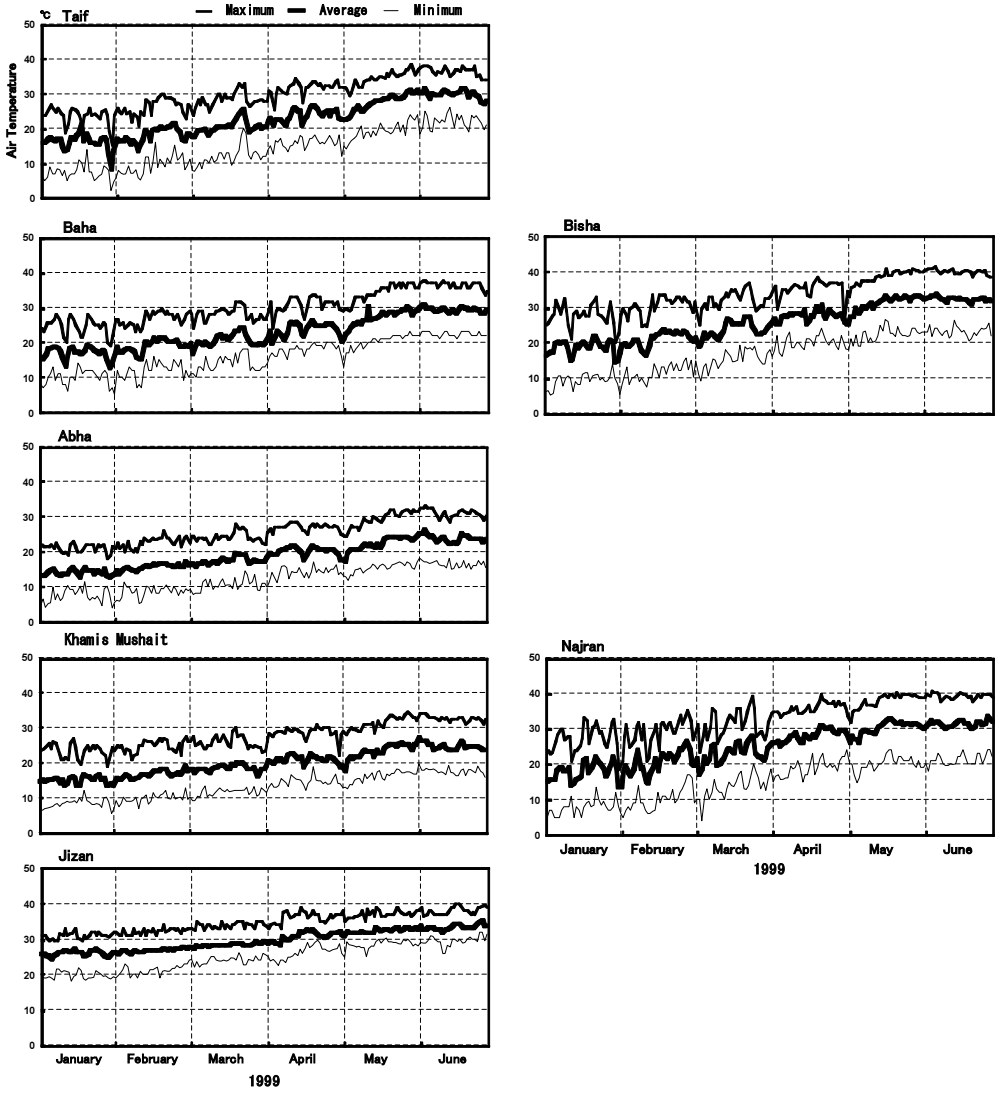


Fig. 1-44. Daily maximum, daily average, and daily minimum air temperature in seven cities around the Asir Mountains from January to June 2000 (from data of MEPA)

July to December 2000

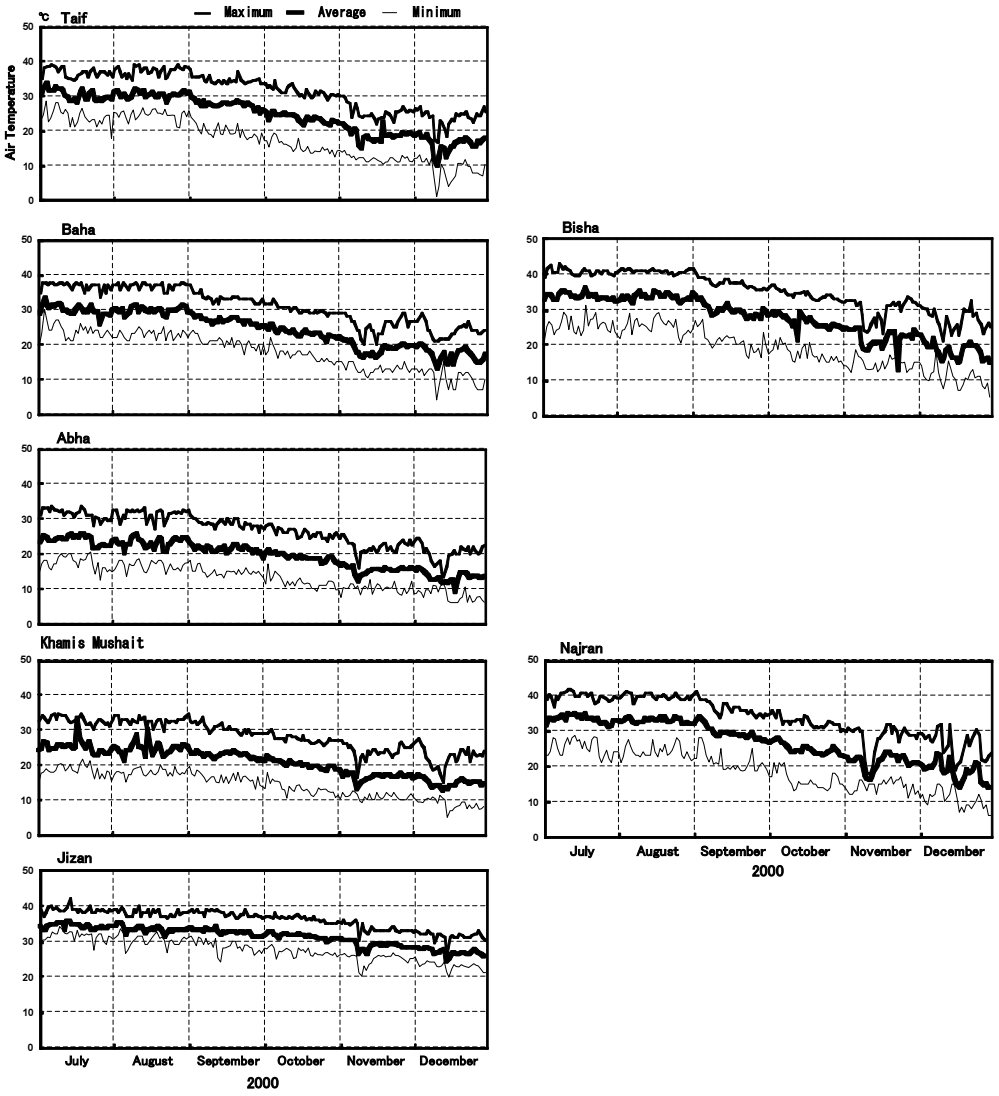


Fig. 1-45. Daily maximum, daily average, and daily minimum air temperature in seven cities around the Asir Mountains from July to December 2000 (from data of MEPA)

January to June 2001

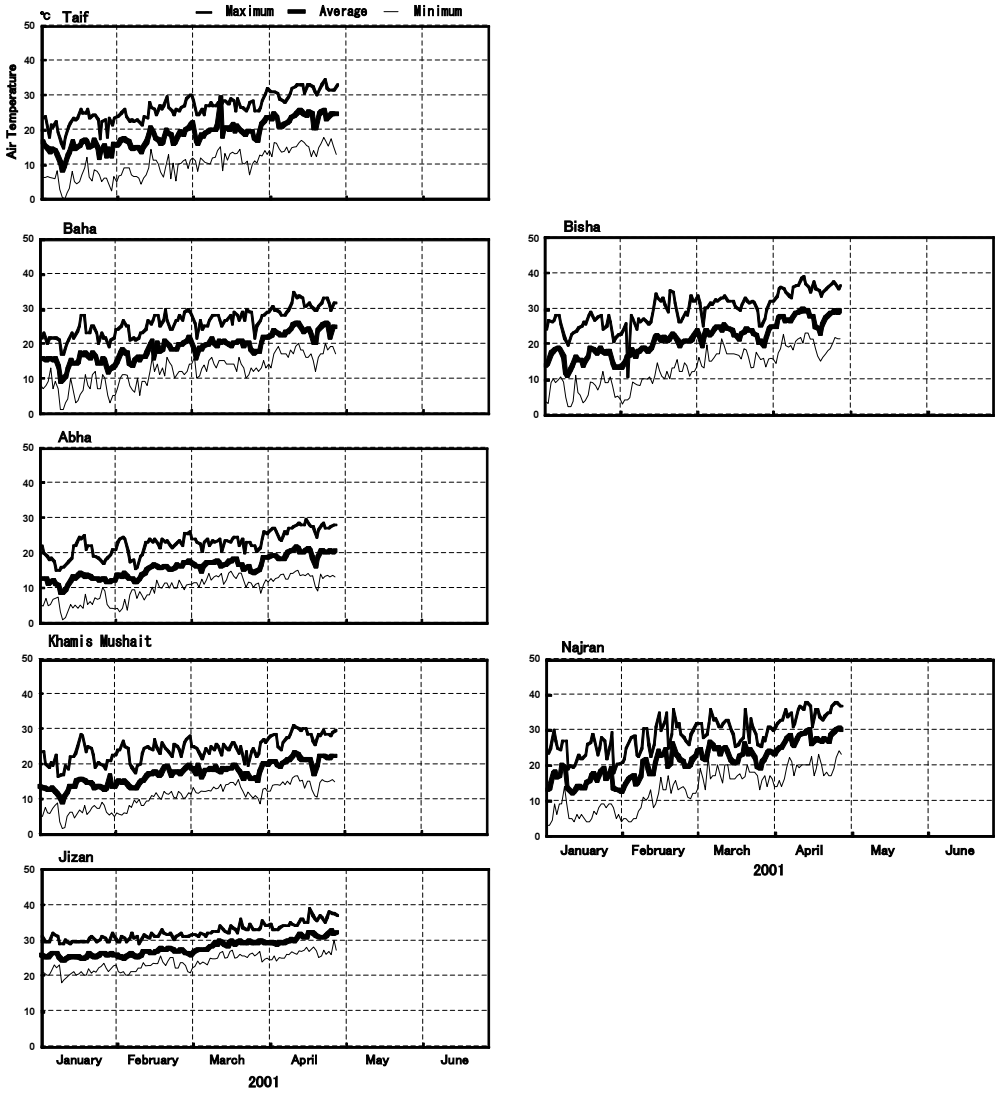


Fig. 1-46. Daily maximum, daily average, and daily minimum air temperature in seven cities around the Asir Mountains from January to April 2001 (from data of MEPA)

July to December 1999

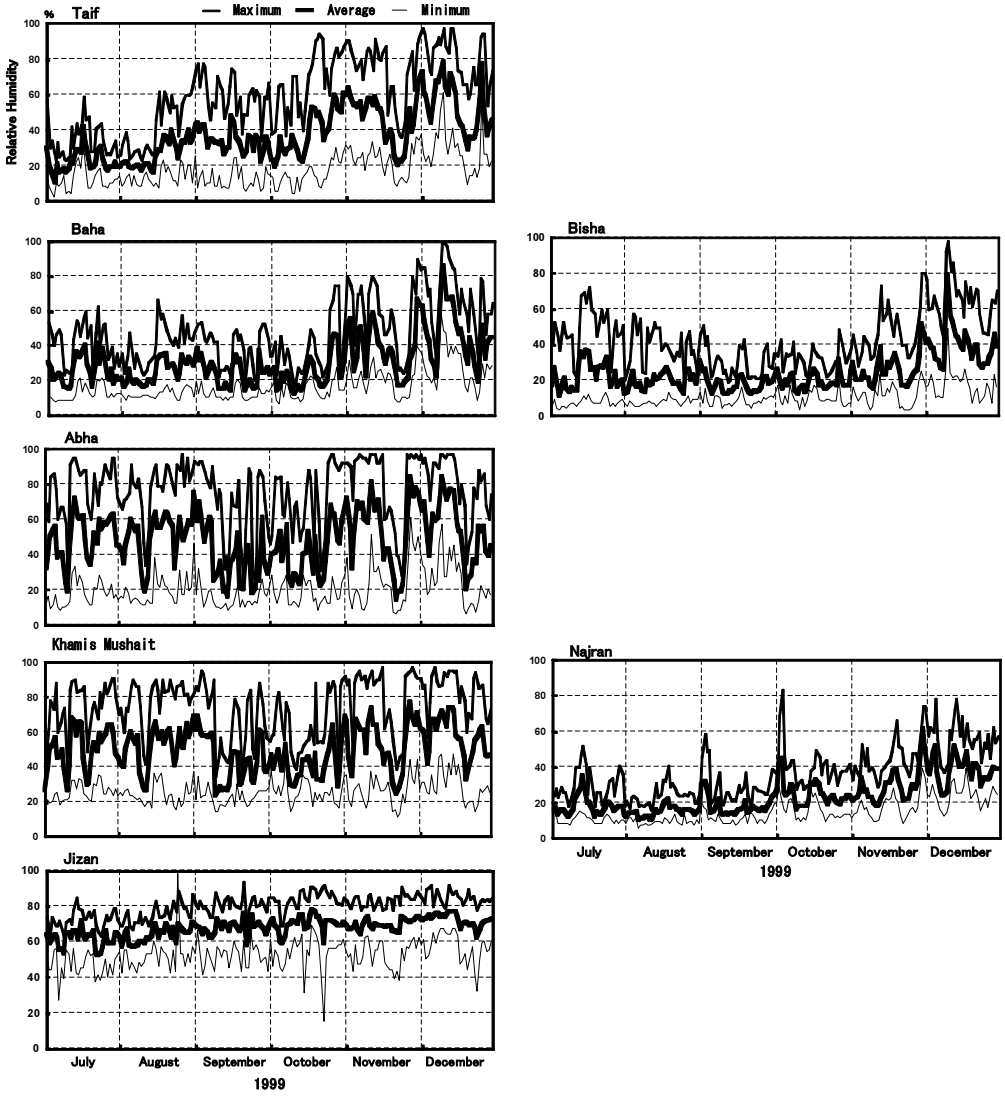


Fig. 1-47. Daily maximum, daily average, and daily minimum relative humidity in seven cities around the Asir Mountains from July to December 1999 (from data of MEPA)

January to June 2000

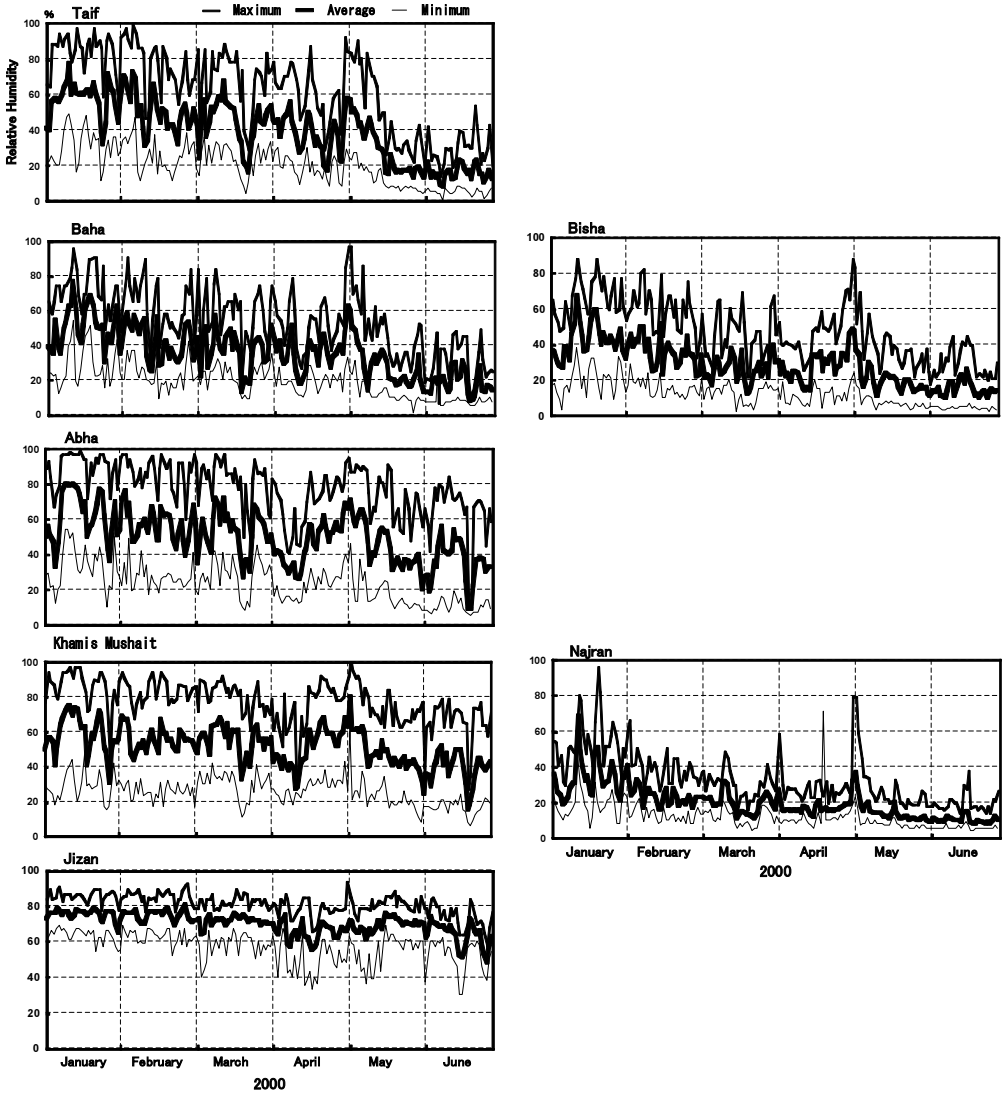


Fig. 1-48. Daily maximum, daily average, and daily minimum relative humidity in seven cities around the Asir Mountains from January to June 2000 (from data of MEPA)

July to December 2000

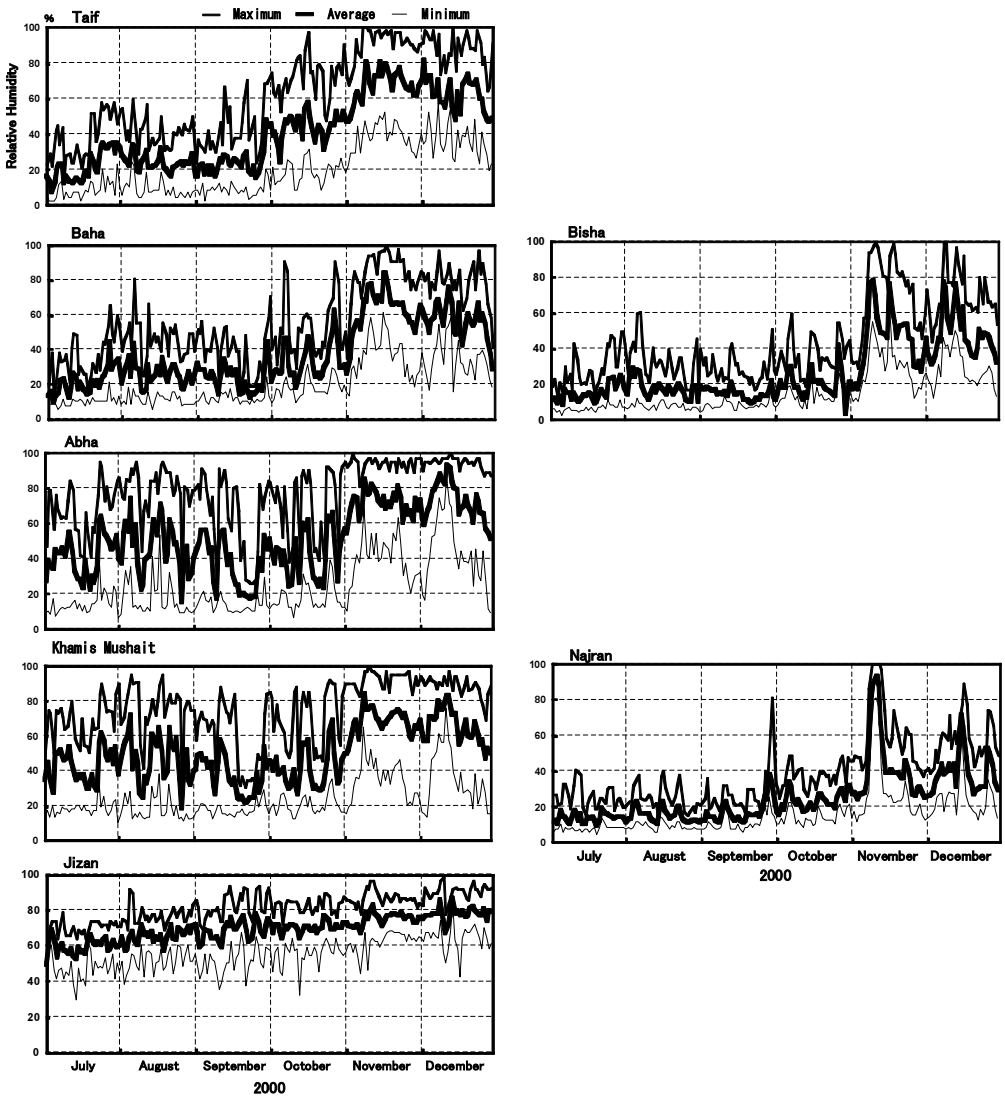


Fig. 1-49. Daily maximum, daily average, and daily minimum relative humidity in seven cities around the Asir Mountains from July to December 2000 (from data of MEPA)

January to June 2001

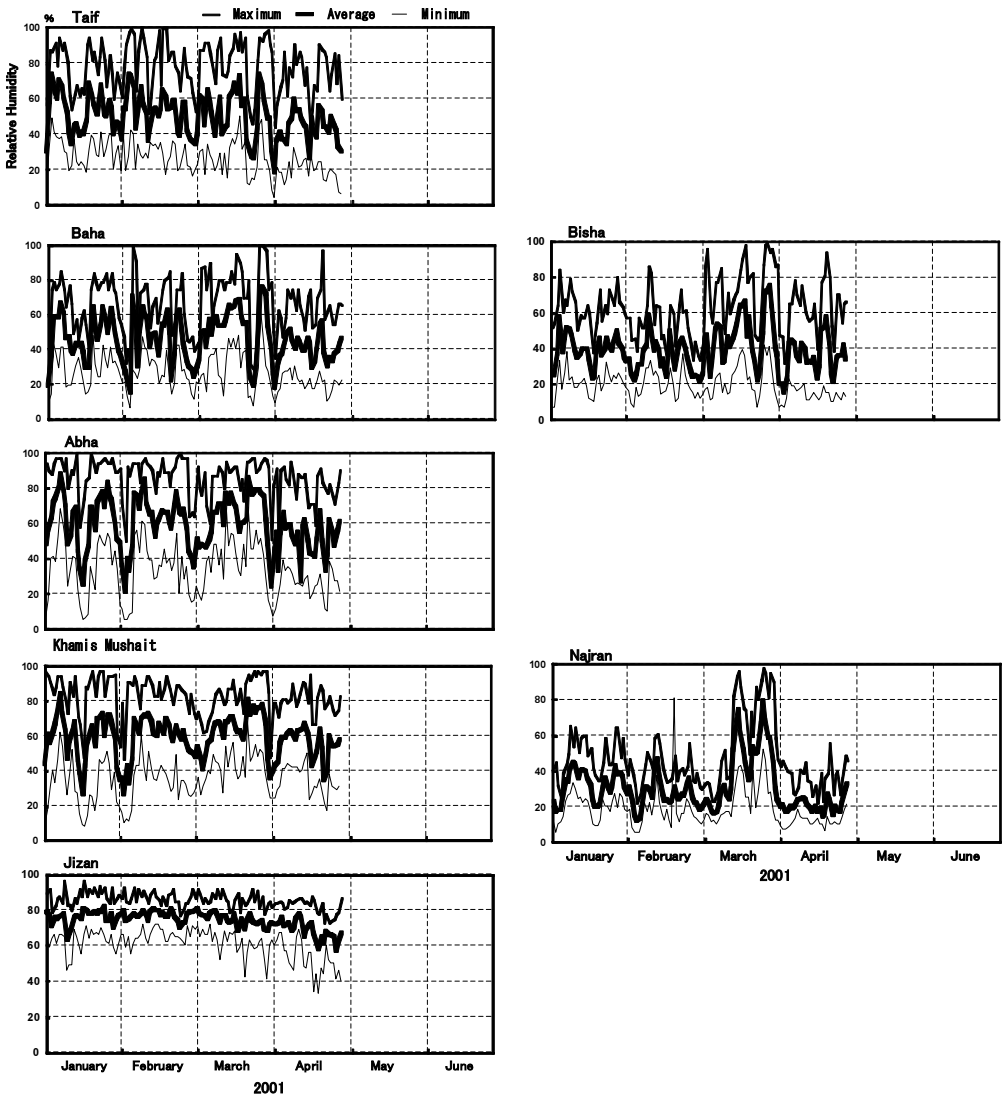


Fig. 1-50. Daily maximum, daily average, and daily minimum relative humidity in seven cities around the Asir Mountains from January to April 2001 (from data of MEPA)

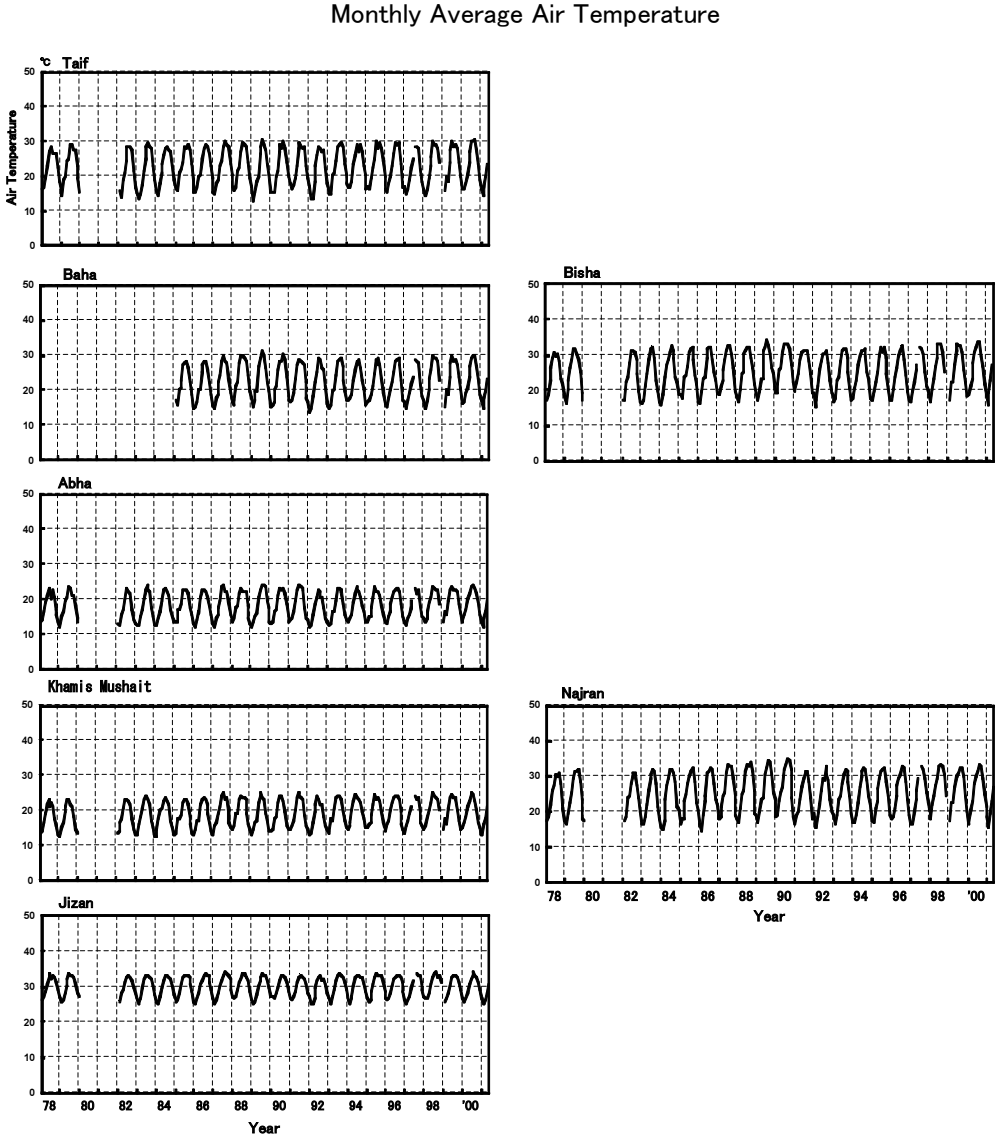


Fig. 1-51. Monthly average of air temperature in seven cities from January 1978 to April 2001 (from data of MEPA)

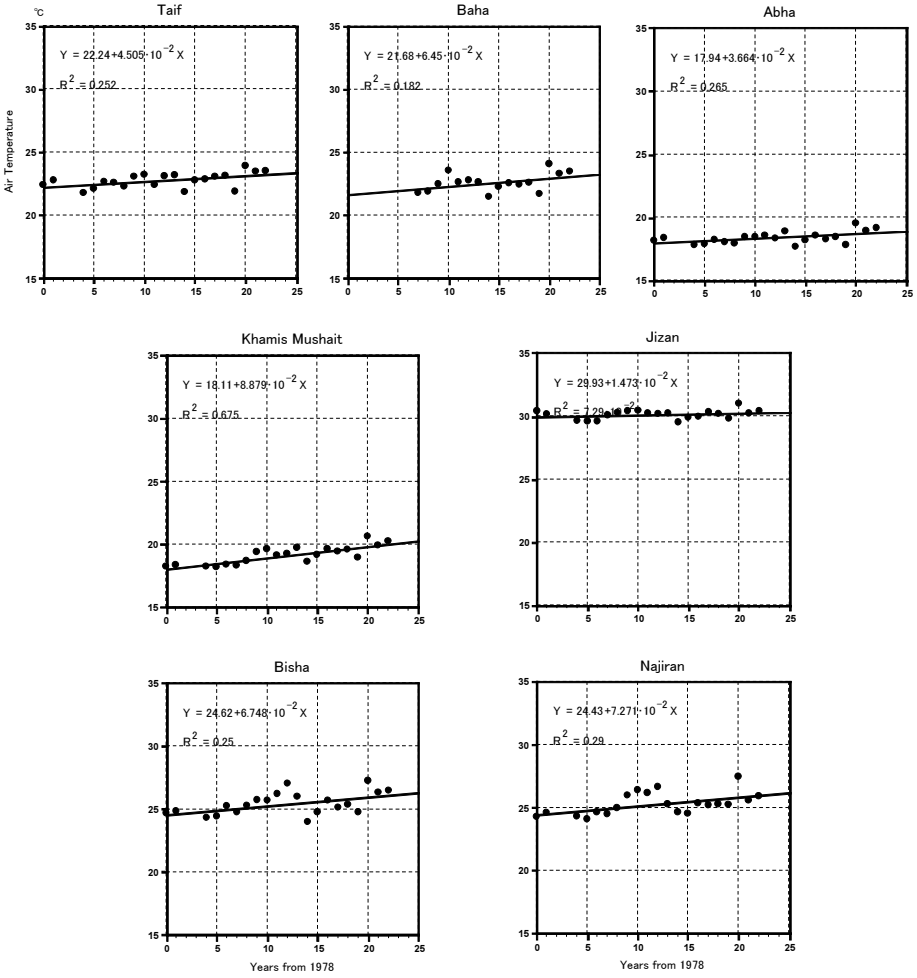


Fig. 1-52. Change of annual average air temperature in seven cities from 1978 to 2001 (calculated from data of MEPA)

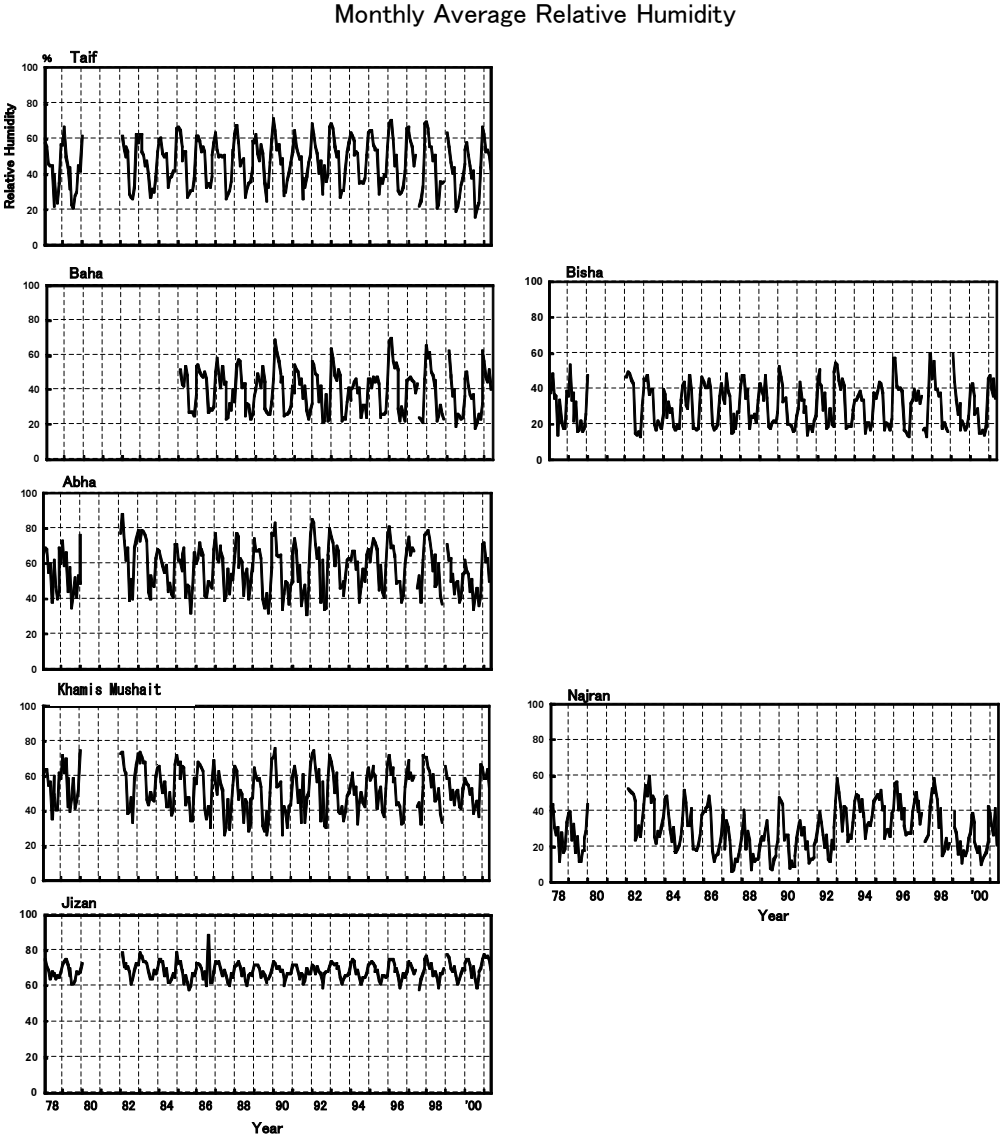


Fig. 1-53. Monthly average of relative humidity in seven cities from January 1978 to April 2001 (from data of MEPA)

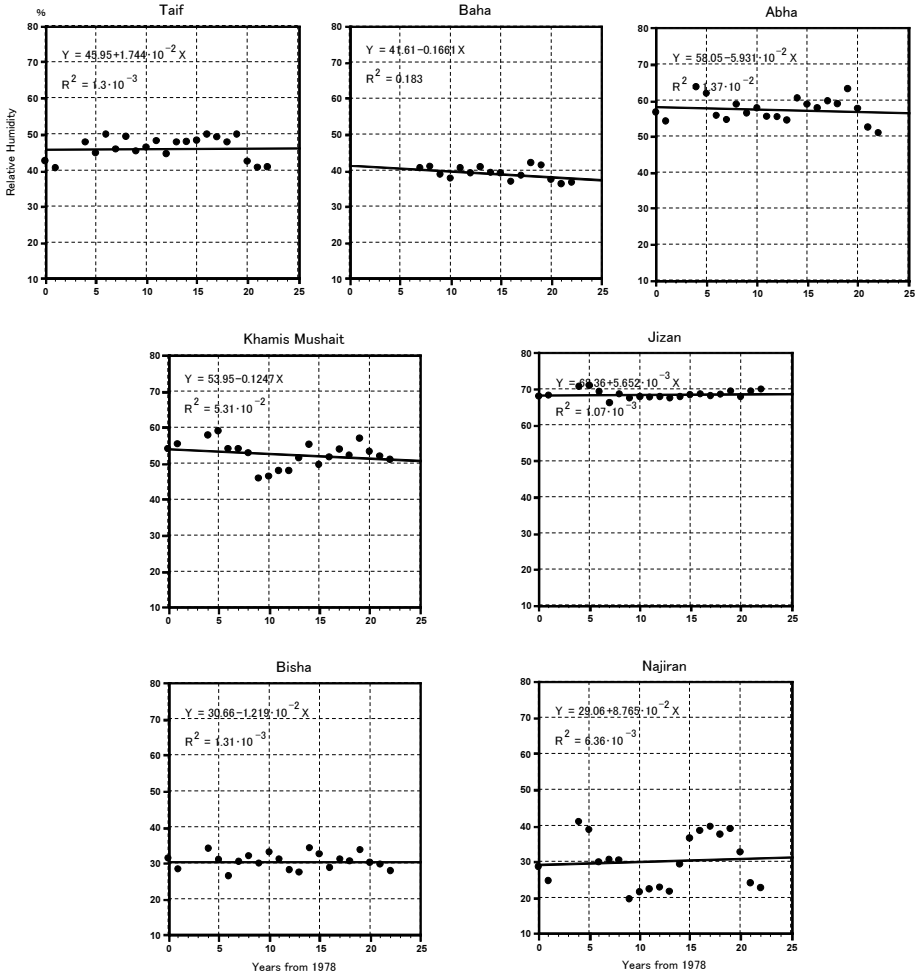


Fig. 1-54. Change of annual average relative humidity in seven cities from 1978 to 2001 (calculated from data of MEPA)

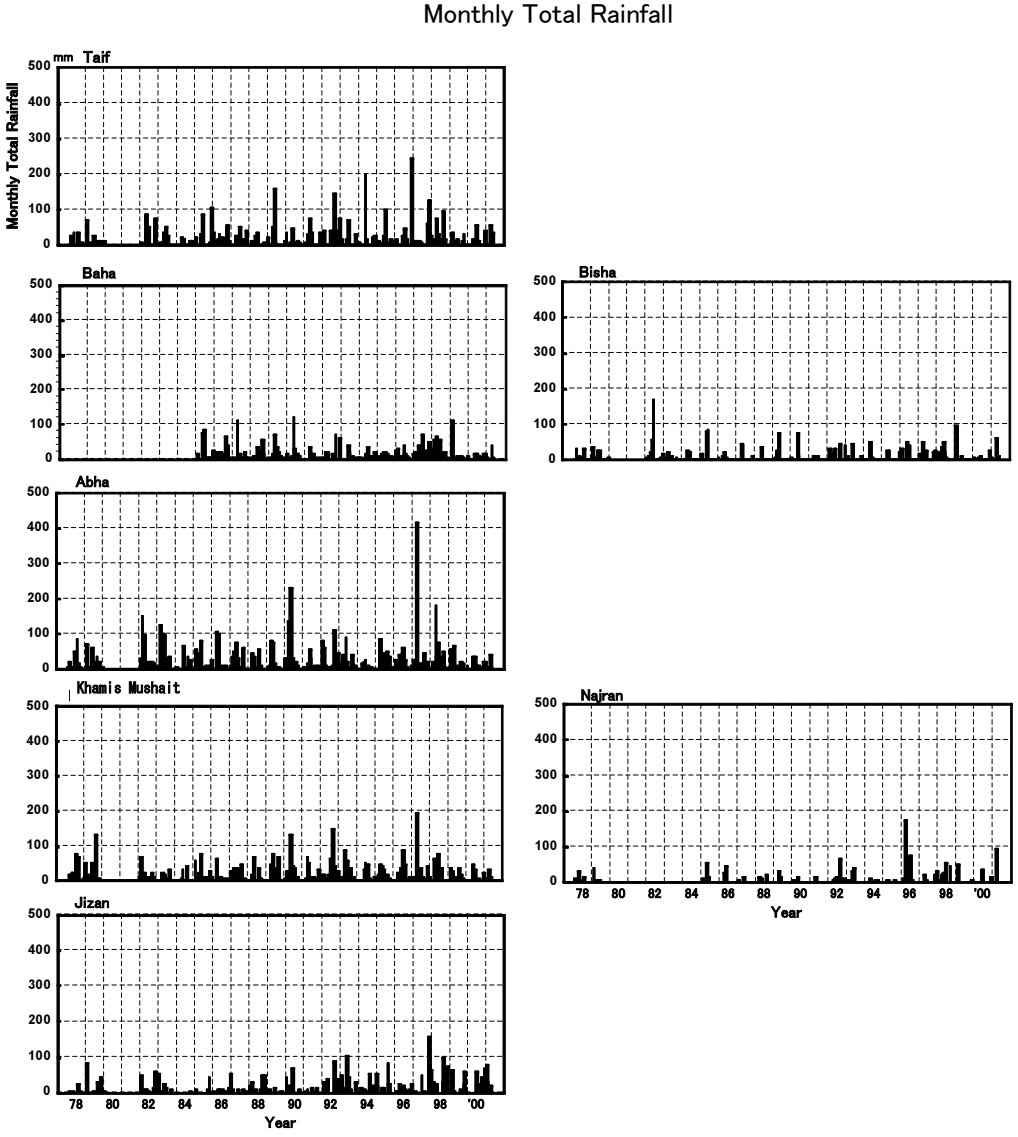


Fig. 1-55. Monthly total rainfall in seven cities from January 1978 to April 2001
(from data of MEPA)

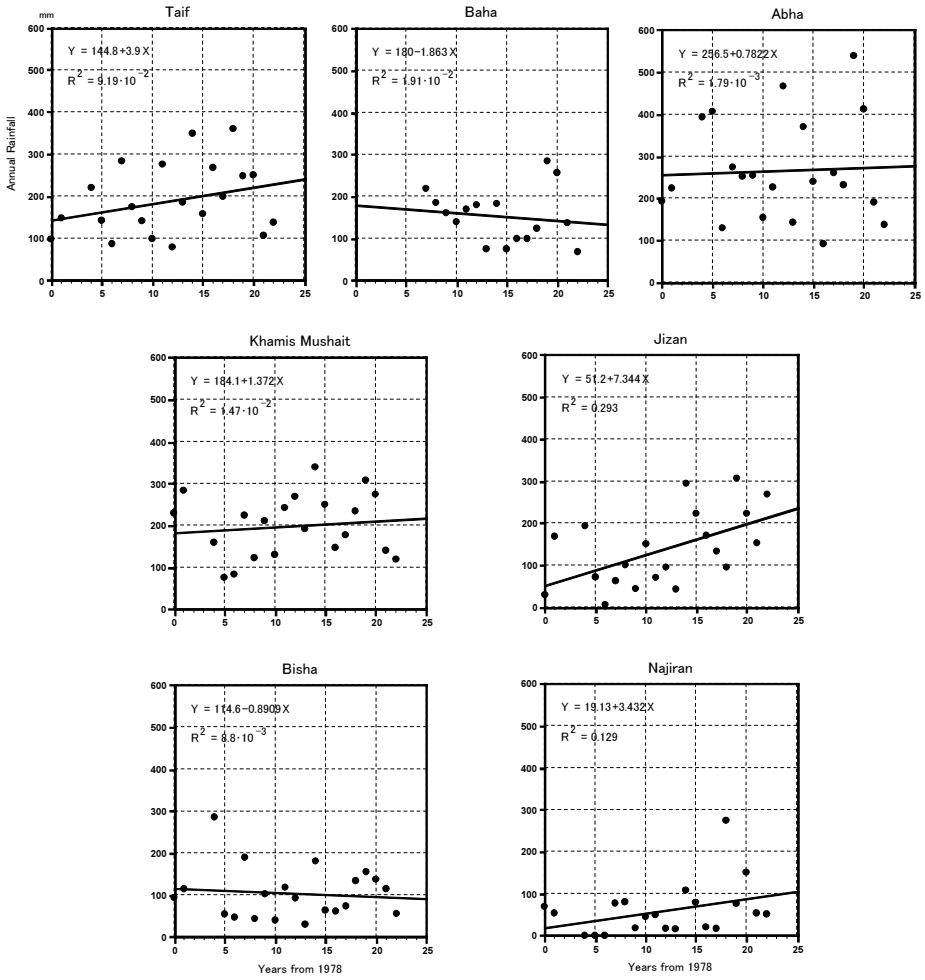


Fig. 1-56. Change of annual rainfall in seven cities from 1978 to 2001 (calculated from data of MEPA)

2 Seed dissemination, regeneration, and germination of *Juniperus procera*

Fukuju Yamamoto, Mahdi M. Al-Mutawa, Haruo Takayama, Tarik Al-Abbasi, Masaji Saito, H. Kawakami, and T. Honma

2.1 The role of animals in the seed dissemination and regeneration

Juniperus procera is a dioecious, tree found above 2,000 m in the mountains of Asir region of Saudi Arabia. The plants are dependent on mist and clouds for moisture in addition to the cooler air at high elevations (Collenette, 1999).

Over the past hundred years, many juniper forests in this region have disappeared for various reasons, including human activities and prolonged drought. It is important to study the ecological mechanisms of both forest deterioration and regeneration to determine the best ways to conserve these fragile juniper woodlands.

Various conifers, such as *Pinus*, *Larix*, *Abies*, *Picea*, *Cedrus*, *Tsuga*, *Cunninghamia*, *Sciadopitys*, *Taxodium*, *Metasequoia*, *Cryptomeria*, and *Chamaecyparis* have seeds disseminated by wind (anemochoric). In contrast, *Podocarpus* and *Taxus* have seeds disseminated by animals (zoochoric). Although it is also speculated that the seeds of *Juniperus* are disseminated by gravity (barachoric), the type of dissemination in *Juniperus procera* has not been observed exactly.

The blue-black ripe cones of Juniperus procera are sweet, indicating that they contain sucrose or other sugars. In July and August, the feces of birds and baboons contain many seeds of *J. procera*, indicating the probability that those animals are the disseminators of the seeds. Goats pastured in the forests of *J. procera* also frequently eat the ripe cones, but whereas birds and baboons tend to swallow the cones and excrete seeds without damaging them, goats may destroy most of the seeds by rumination. Ruminants may, therefore, not play a role in either disseminating the seeds or in tree regeneration of the juniper forests. Very little information about the roles of animals, including ruminants, in seed dissemination and forest regeneration is available.

Materials and methods

Seeds in animal feces

On 27 July, 12 samples (totaling 4.4 g) of bird feces were collected from rocks and the meteorological tower in the forest of the Raydah Nature Reserve, Abha, in the Asir region of Saudi Arabia. The feces were estimated to be from three bird species: Tristram's grackles

(*Onychognathus tristramii*), yellow-vented bulbuls (*Pycnonotus xanthopygos*), and Yemen thrushes (*Turdus menachensis*) (Porter et al., 1996). Eleven samples of baboon feces (*Papio hamadryas*) and 150 samples from goats (*Capra aegagrus*) were collected on rocks and in the forest on the same day. The feces were air-dried, weighed, and sifted with a 1 x 1 mm mesh sieve in tap water at the NCWCD Research Center, Abha to collect plant seeds and their fragments.

Sizes, dry weights, and seed number of juniper cones

Many ripe and unripe cones of *J. procera* were also taken from trees in the same forest. The diameters of 50 ripe and 50 unripe cones, the fresh weight of 100 ripe and 100 unripe cones, and the seed number per ripe fruit (n=100) were determined at the Center. About 67 g of ripe cones (495 cones) were separated into seeds and pericarp. About 50 g of unripe cones were cracked with a hammer. The weighed ripe and unripe cones, the pericarp of the ripe cones, and the cracked unripe cones were dried at 70°C for 48 hours using a convection oven (ESPEC LC-222), and the dry weights of each were determined.

Results and discussion

Table 2-1 shows cone diameter, dry weight, and number of seeds per cone. The ripe cones were slightly smaller than unripe cones. The number of seeds per cone averaged about 3.5.

Seeds of both juniper and *Opuntia ficus-indica* were obtained in one sample of baboon feces, indicating that both *Opuntia ficus-indica* fruits and juniper cones are used for food by baboons. The numbers of seeds from the collected feces are shown in Fig. 2-1. In the bird feces, all juniper seeds were counted. Over 40 seeds/g of bird feces were counted. The number of *Opuntia ficus-indica* seeds was greatest in the feces of baboons. On average, about 1.2 juniper seeds/g of baboon feces were counted, but 66 seeds were found in one sample.

Only four intact juniper seeds were taken in the 150 samples of goat feces (30.5 g air-dried weight). In contrast, many seed fragments of junipers were obtained in the goat feces.

It was concluded that birds play the most important role in seed dissemination of junipers. Baboons play a role in the dissemination of juniper seeds, but they also spread many seeds of *Opuntia ficus-indica*, which, as an invasive species, may cause ecological damage to the juniper forests.

Goats prefer to eat the ripe cones of junipers, but the number of seed fragments in their feces exceed the number of intact seeds. Many small seed fragments may also have fallen through the

mesh of the sieve during washing. These results indicate that most of the seeds eaten by goats are smashed into small pieces during mastication and digestion.

2.2 Seed germination

Knowledge of the physiological characteristics of seed dormancy and germination of *Juniperus procera* is essential for undertaking the regeneration and recovery of the declining juniper forests in the Asir region. As such, this study deals with the rate of seed germination, treatments that promote germination, and hormonal factors involved in germination.

Methods

Treatments to promote seed germination

Seeds of *Juniperus procera* were collected in the Raydah Nature Reserve, Abha, in October 1996, carried to Tottori University, and stored at 4℃ in a refrigerator until January 1997. The mean length of the seeds was 1.61±0.37 mm and the diameter was 0.91±0.73 mm (n=100). At the beginning of the experiments, the germination rate for 100 seeds was determined by placing untreated seeds on wet filter paper set up in plastic petri dishes at 26℃ and placing them in total darkness for days. The rate of germination for normal seeds, immature seeds, and insect-eaten seeds was 85.6, 7.2, and 7.2%, respectively.

To test treatments to increase germination, 1,400 seeds were selected and divided into 14 groups of 100 seeds each.

Physical and chemical treatments

Treatments for promoting seed germination by physical and chemical methods were as follows: 1) control, 2) dipping in concentrated H_2SO_4 for one minute, 3) dipping in concentrated H_2SO_4 for five minutes, 4) dipping in concentrated H_2SO_4 for 30 minutes, 5) dipping in concentrated H_2SO_4 for one hour, 6) dipping in concentrated H_2SO_4 for two hours, 7) scarifying with sandpaper for 30 seconds, 8) scarifying with sandpaper for one minute, 9) dipping in boiling water for one minute, 10) dipping in boiling water for five minutes, 11) dipping in boiling water for 10 minutes, 12) soaking in water for 24 hours, 13) soaking in water for five days in room temperature , and 14) soaking in water for ten days.

Hormonal treatments

The plant growth regulators GA_3 and (+)ABA were used to promote seed germination. The concentrations of both hormones were 0, 0.01, 0.1, 1, 10, 100, and 1000 ppm. For each treatment, 150 seeds were used. The seeds were dipped in each solution for 72 hours, rinsed in 0.5% sodium hypochlorite and then in 0.05% sodium hypochlorite, and finally washed in sterilized water.

The germination rate of physically, chemically, and hormonally treated seeds was examined in seeds placed on wet filter paper set up in plastic petri dishes at 26°C and placed in total darkness.

Results and discussion

Fig. 2-3 shows the of germination rates of physically and chemically pretreated seeds. The treatments using concentrated H_2SO_4 for 30 minutes and one hour, wounding with sandpaper for 30 seconds and one minute, and soaking in water for one and five days increased the rate of germination. The results indicate that the hard seed testa is a possible inhibiting factor for the germination of seeds of *Juniperus procera*.

Figs 2-3 and 2-4 show the germination rate of GA_3 and (+) ABA (a kind of hormone) treated seeds. A high level (1000 ppm) of GA_3 significantly increased the rate of seed germination, indicating the importance of GAs in seed germination of various kinds of plants.

In contrast, a low level (0.01 ppm) of (+) ABA increased the rate of seed germination (Fig. 2-5). There is little information about ABA as a promoting factor for seed germination.

We then tried to determine changes in endogenous ABA at various stages of seed germination in *Juniperus procera*. Mature seeds were selected, sterilized, placed in petri dishes, and incubated at 26℃ in total darkness. The seeds were harvested at four different stages including 1) dormant stage, 2) water-absorbing stage, 3) testa-separating stage and 4) germinating stage.

The seeds of each stage were crushed and the ABA was extracted with 80 acetone, purified, and fractioned using ODS-HPLC. The ABA content in the fractions were quantified using ELISA. The results of the ABA extraction are shown in Fig. 2-5. The ABA content drastically increased at the water absorbing stage, suggesting that ABA has an important role in the first stage of seed germination of *J. procera*. These are the first observations to show the possible role of ABA in seed germination. More information is needed, however, to clarify the mechanisms of seed germination.

As a conclusion, *Juniperus procera* has a high potential for natural regeneration because of the ability of the seeds to germinate. The pre-treatments described above, especially treatments using GAs, are effective, especially if growing seedlings for artificial reforestation is desired.

2.3 Drought tolerance and changes in contents of endogenous ABA in *Juniperus procera* seedlings.

2.3.1. Introduction

Juniperus procera trees distributed in Asir region, the Kingdom of Saudi Arabia, are growing under stressful environments. Although die-back or die-off phenomena occurring in their woodlands are estimated to be caused by periodic or long term drought stresses, the physiological or ecological mechanisms of them are still obscure. To solve these problems, it is necessary to study the physiological responses of these species to severe or moderate drought stress in model experiments. In the present study, the effects of long-term drought stress on the growth, stress acclimation and ABA accumulation in needle leaves of Juniperus procera seedlings were studied. The experiments for this study consist of two parts as follows:

(1) Effects of severe and moderate stresses for long period on the growth and development of Juniperus procera seedlings.

(2) Effects of sharp drought stress on xylem pressure potential and changes in ABA contents in severe- or moderate-stress experienced Juniperus procera seedlings.

2.3.2 Materials and methods

(1) Effects of severe and moderate stresses for long period on the growth and development of *Juniperus procera* seedlings.

The seedlings of *Juniperus procera* were grown from seeds collected in the juniper woodland of Raydah Nature Reserve in March and sowed in Tottori, Japan in April, 1998. Potted, 3-year-old seedlings were obtained in March, 2001. At the end of May, the seedlings were transplanted into plastic pots. Soil in the pots was composed of granite sand and vermiculite (5:1). The diameter and height of the pots were 12 and 11cm, respectively. Before transplanting, relationship between the pF values and water contents of the soil was determined.

The seedlings were divided into three groups: 1) non-stressed control, 2) moderately stressed (pF 2.5), and severely stressed (pF 3.5). The soil water content of stressed seedlings was adjusted at pF 2.5 or 3.5 by weighing the total weights of pots every day for about 7 weeks from July 30 until September 13, 2001. The control seedlings were watered every other day. Each seedling was fertilized weekly with a 100ml of 1/1000 Hyponex solution, a liquid fertilizer, containing N, P, and K (10:3:3).

Changes in seedling heights and stem diameters at 1cm above the soil level were measured with a digital caliper and a micro caliper, respectively.

On September 13, six seedlings of each group were selected and xylem pressure potentials for them were determined before dawn (3 plants) and sunset (3 plants) using a pressure-chamber (PMS 600).

On September 19, 7 seedlings of each group were selected, separated into needle leaves, stems and roots and oven-dried at 80℃ for 48h to determine the dry weight of each plant part.

(2) Effects of sharp drought stress on xylem pressure potential and changes in ABA contents in severe- or moderate-stress experienced *Juniperus procera* seedlings.

Experiments

Nine seedlings of each group were carried into a growth cabinet in the Arid Land Research Center, Tottori University. Day-night temperatures, humidity, irradiation and photoperiod in the cabinet are 28-25℃, 30%, 80000 lux and 12hours, respectively. The seedlings were watered and kept under darkness at 25℃ and 30% humidity for 12 hours in the cabinet.

The soil in pots of seedlings were dipped in ice water for cooling root system to check water uptake from soil for the purpose of causing sharp water stress in plants. Then, changes in xylem pressure potential of shoots were determined at 6 and 12hours after stress initiation. The sampled shoots were frozen with dry ice and stored in a freezer at –80℃. Fig. 2-6 indicates changes in air and soil temperature before and after the initiation of soil cooling.

The remaining 9 seedlings of each group were watered every day in the cabinet under the same condition for 7 days, then, the same experiments were performed as described above.

Quantitative analysis of ABA

From each of 3 seedlings in each group, 3g of current-year needle leaves were sampled and combined together. The combined samples were dipped in 80％(v/v) acetone, dispersed with Polytron (KINEMATICA PT 2100) and extracted for 3 times. The extracted solution was concentrated with a rotary vacuum evaporator (EYELA N-N), adjusted at pH2.5 with 6N H_2SO_4 and extracted 3 times with toluene to remove resin and pigments. The water phase of them was extracted with dichloromethane for 3 times. The dichloromethane phase was extracted 3 times with saturated $NaHCO_3$ solution. The $NaHCO_3$ solution phase was adjusted at pH 2.3 with 6N H_2SO_4 and extracted 3 times with dichloromethane. The dichloromethane phase was dehydrated through a glass column

packed with anhydrous Na_2SO_4 and concentrated to dryness. The dried extractive was diluted with 5% methanol, passed through a Sep-pak column to remove water-soluble substances with 5% methanol, then, passed through 60% methanol and concentrated to dryness. The extractive containing ABA was purified and fractionated by HPLC on a column of CAPCELLPAK C_{18} (6.0mm ϕ ×150mm) . The ABA fraction was concentrated to dryness to determine ABA contents using ELISA.

Data were statistically analyzed by Sheffe's test.

2.3.3 Results

(1) Effects of severe and moderate stresses for long period on the growth and development of *Juniperus procera* seedlings.

Fig. 2-7 indicates the shoot elongation of non-stressed and stressed junipers. On and after August 8, water withholding significantly suppressed the shoot growth of junipers. On August 22 and September 5, the reduction in the shoot elongation of seedlings stressed at pF 3.5 was more remarkable than that of the seedlings at pF 2.5.

There is no difference in stem diameter increment among three stress treatments (data are not shown).

Fig. 2-8 indicates the dry weights of plant parts. The severe water stress showed a tendency to reduce the biomass increment of needles, roots and the total in juniper seedlings, although there was no significance among the data.

Fig. 2-9 indicates changes in xylem pressure potential (XPP) of non-stressed and stress-experienced *Juniperus procera* seedlings at pre-dawn and pre-sunset. Before dawn, there was no significant difference in XPP among three groups. However, before sunset, the XPP of the stress-experienced seedlings was significantly lower than that of control plants. The severely stressed seedlings at pF 3.5 indicated serious water stress more than the moderately stressed seedlings at pF 2.5.

(2) Effects of sharp drought stress on xylem pressure potential and changes in ABA contents in severe- or moderate-stress experienced *Juniperus procera* seedlings.

Fig. 2-10 indicates changes in the XPP of non-stressed and stress-experienced *Juniperus procera* seedlings before and after root cooling started at 12hrs after the initiation of re-irrigation. Within 6 hours, the XPP of the seedlings in every group rapidly decreased after the initiation of root

cooling. There was no significant difference in XPP among three groups at 6 or 12 hours after the stress initiation.

Fig. 2-11 indicates changes in the XPP of non-stressed and stress-experienced *Juniperus procera* seedlings before and after root cooling started at 1 week after the initiation of re-irrigation. The XPP of the seedlings in every group rapidly decreased at 6 hours after the initiation of root cooling. At 12 hours, the XPP of the non-stressed seedlings showed a tendency to recover in comparison with that of the stress-experienced seedlings. However, there was no significant difference among three groups.

Fig. 2-12 indicates changes in the ABA contents of non-stressed and stress-experienced *Juniperus procera* seedlings before and after root cooling started at 12hrs after the initiation of re-irrigation. There was no significant difference among the seedlings of three groups before the initiation of root cooling. At 6 hours after the root cooling, however, the ABA content in the moderately stressed seedlings at pF 2.5 showed the greatest value in comparison with other two groups.

Fig. 2-13 indicates changes in the ABA contents of non-stressed and stress-experienced *Juniperus procera* seedlings before and after root cooling started at 1 week after the initiation of re-irrigation. There was no significant difference among the seedlings of three groups before the initiation of root cooling as Fig. 2-11. However, at 6 hours after the root cooling, the ABA content in the seedlings of non-stressed control was the greatest among three groups.

2.3.4. Discussion

Severe drought stress at pF 3.5 greatly affects the shoot growth of *Juniperus procera* seedlings. However, no seedling died and little decline was observed in biomass increment under such environment. The shoot elongation of seedlings was also decreased by the moderate stress at pF 2.5 without having biomass reduction. Further, there is no difference in stem diameter increment among the seedlings of three different stress treatments. In our field study for the growth of juniper trees under the natural condition, we have concluded that shoot elongation was relatively sensitive to drought stress in comparison with diameter growth. These results suggest that *Juniperus procera* is sensitive to drought stress rather in shoot elongation than in biomass increment or stem diameter increment.

At 12 hours after re-irrigation, ABA production under sharp decline in water potential caused by root cooling was significant in the moderately stressed seedlings rather than in the severely

stressed or non-stressed seedlings. In general, various investigations demonstrate that ABA is produced in the root system of plants under moderate stress not under severe stress and transported to stems and leaves. In the severely stressed seedlings in the present study, the content of ABA was not significant suggesting that such stress inhibits the production of ABA in this species. In contrast, the moderately stressed seedlings showed much production of ABA at 6 hours after the initiation of root cooling, but not at the beginning of it. These phenomena suggest that not ABA itself but ABA precursors or some substances convertible to ABA may accumulate in the needles of the moderately stressed juniper seedlings. This suggestion may be related to stress acclimation in this species.

The patterns of changes in ABA content in the seedlings kept for 1 week in the growth chamber after re-irrigation were different from that of the seedlings at 12 hours. The ability of ABA production in the moderately stressed seedlings disappeared, whereas that of the non-stressed seedlings increased. These results suggest that the environmental conditions in the chamber may be stressful for the non-stressed seedlings enough to accumulate ABA related substances in needles. In contrast, the moderately stressed seedlings lost the ability to produce ABA, suggesting that the chamber conditions may be non-stressful for them. These results indicate that *Juniperus procera* seedlings can gain the ability of ABA production in needle leaves under weak or moderate stresses. ABA is an important plant growth regulator to cause stomatal closure under drought stress condition. The characteristics of ABA production in *Juniperus procera* may be one of the survival abilities of this species.

Table 2-1
Cone diameters, dry weights, and number of seeds per cone in Juniperus procera

	Diameters (n=50)	Fresh weights (n=100)	Dry weights (n=100)	Seed number / cone (n=100)
	mm	g	g	
Ripe	6.4 ± 0.1	0.14± 0.003	0.10± 0.02	3.5± 0.1
Unripe	6.8 ± 0.1	0.19± 0.005	0.08± 0.00	-

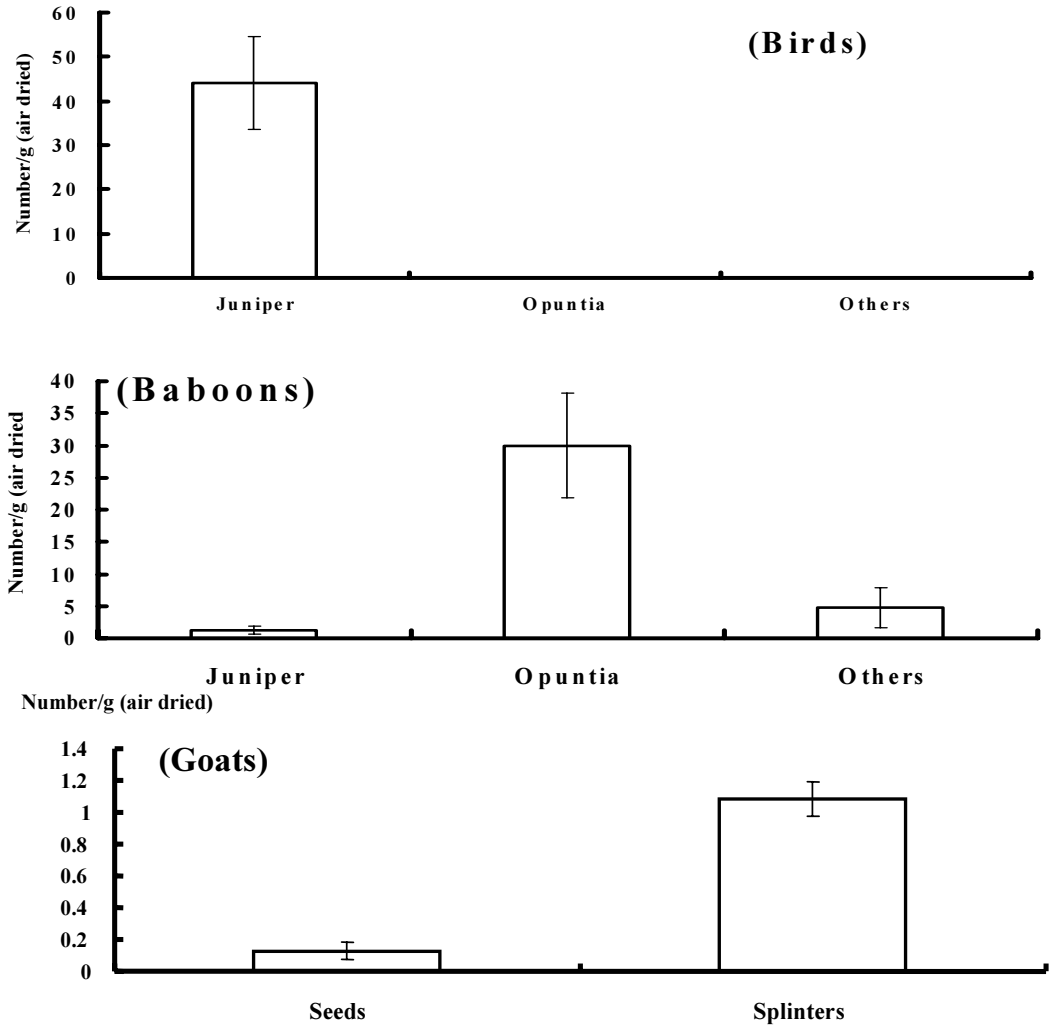


Fig. 2-1 Seeds of *Juniperus Procera,* opuntias, and other plants in the feces of birds (upper), baboons (middle), and goats (lower). Only juniper seeds and their splinters were counted in goat feces.

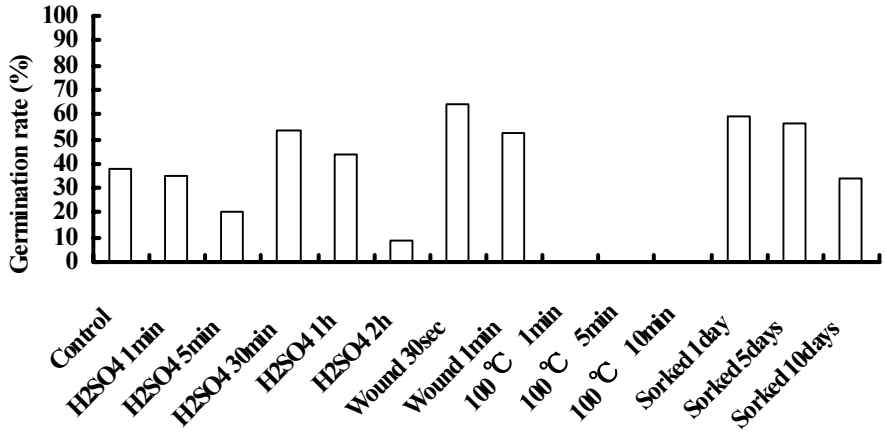


Fig. 2-2. Germination rates of physically or chemically treated *Juniperus procera*

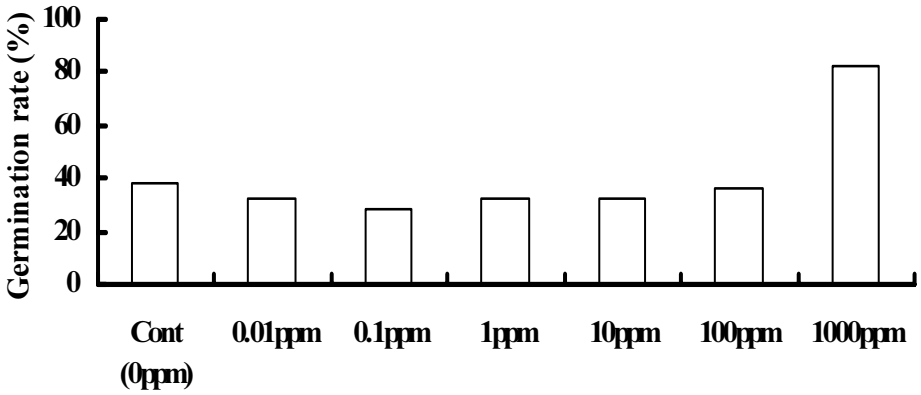


Fig. 2-3. Germination rates of GA_3 treated *Juniperus procera*

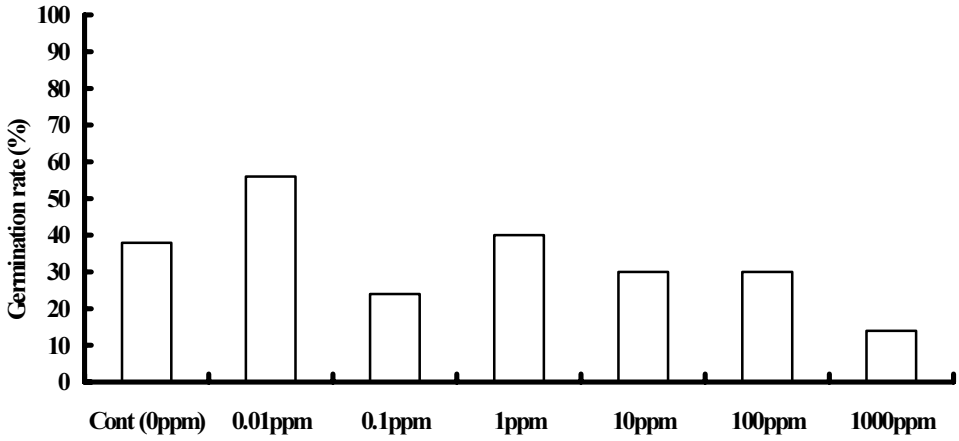


Fig. 2-4. Germination rates of ABA treated *Juniperus procera*

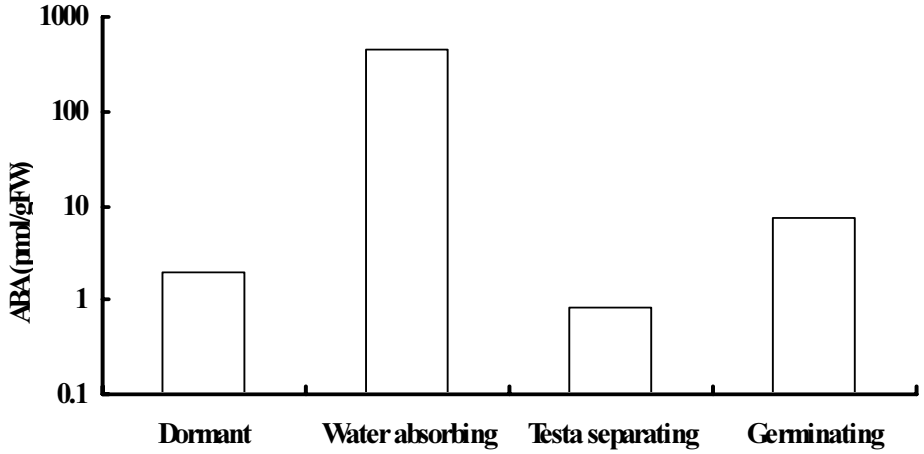


Fig. 2-5. ABA contents in *Juniperus procera* seeds at various germination states

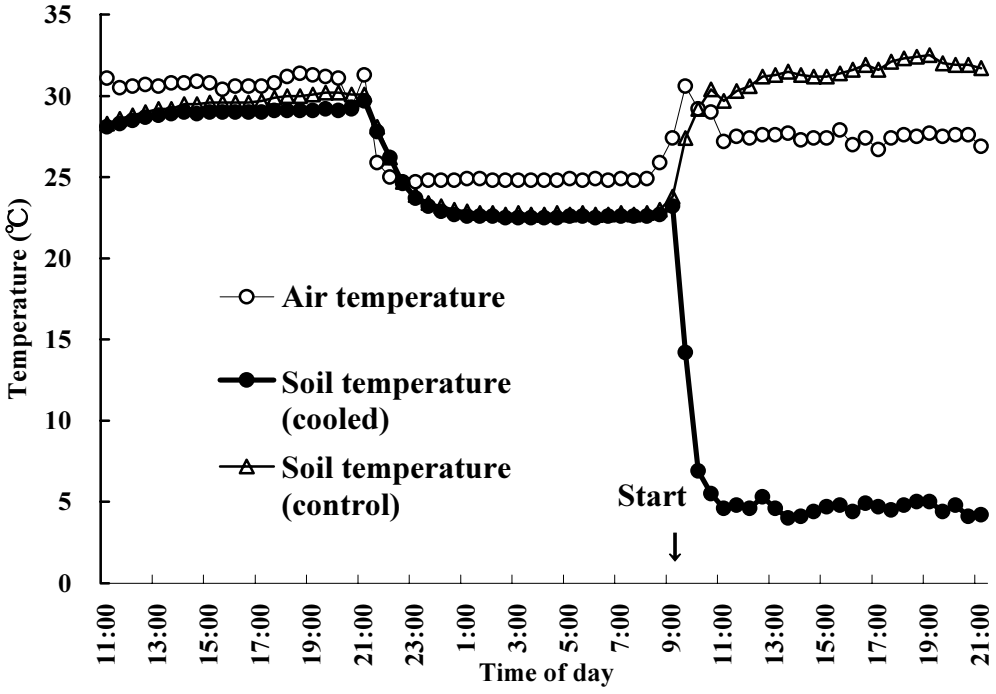


Fig. 2-6 Changes in air and soil temperatures before and after the initiation of root cooling in *Juniperus procera* seedlings.

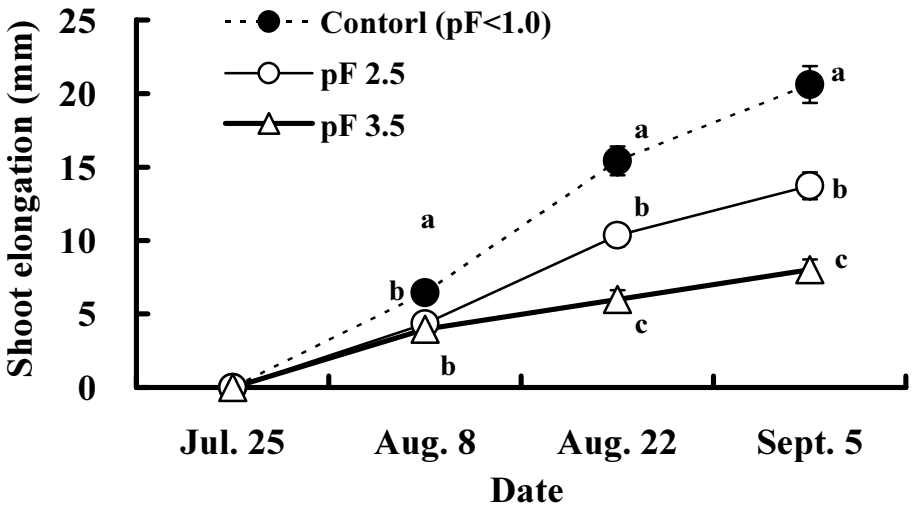


Fig. 2-7 Effects of drought stress on shoot elongation of *Juniperus procera.* Significant differences of the means of each date are indicated by different letters (Scheffe's test, P<0.05).

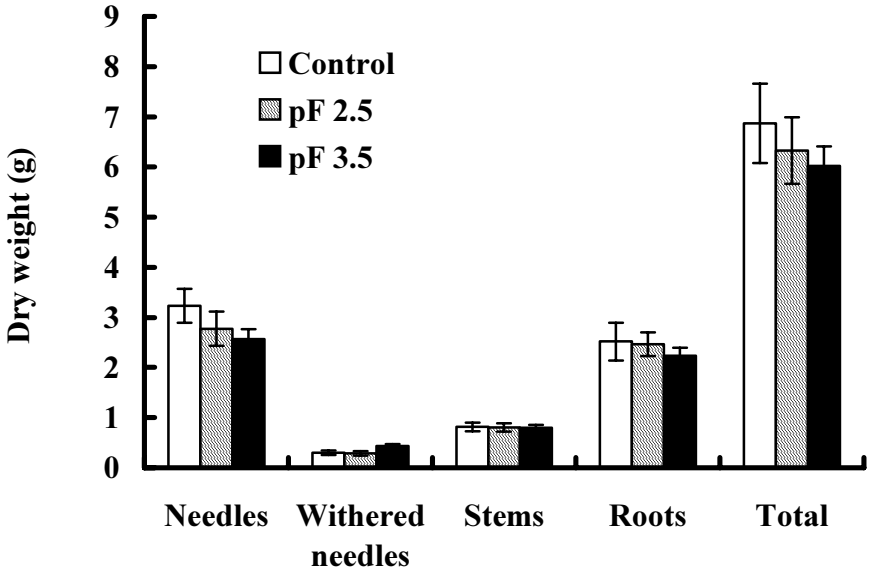


Fig. 2-8 Dry weights of plant parts of *Juniperus procera.*

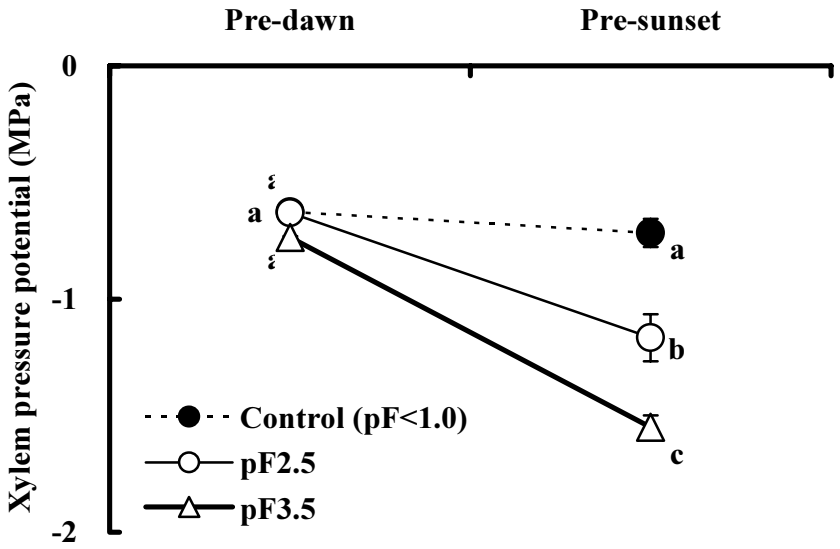


Fig. 2-9 Changes in xylem pressure potential of non-stressed and stress-experienced seedlings of *Juniperus procera* at pre-dawn and pre-sunset. Significant differences of the means of each time are indicated by different letters (Scheffe's test, P<0.05).

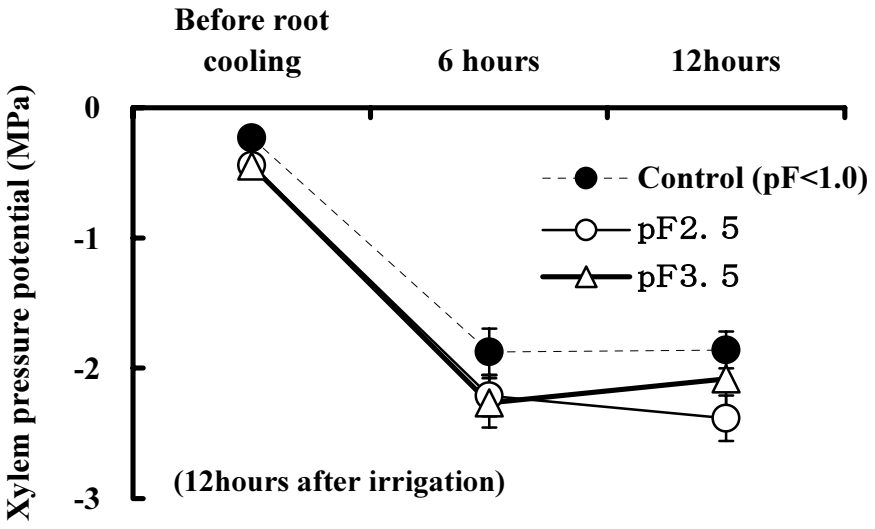


Fig. 2-10 Changes in the xylem pressure potential of non-stressed and stress-experienced seedlings of *Juniperus procera* before and after root cooling started at 12hrs after the initiation of re-irrigation.

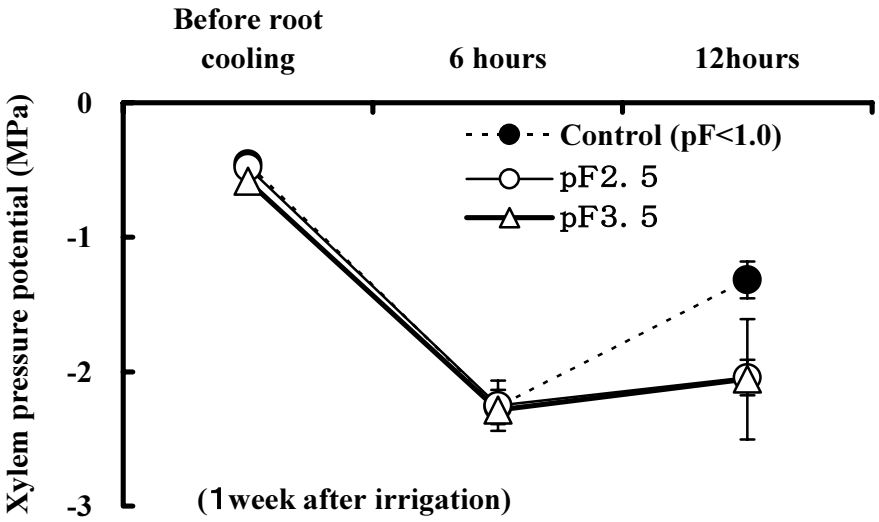


Fig. 2-11 Changes in the xylem pressure potential of non-stressed and stress-experienced seedlings of *Juniperus procera* before and after root cooling started at 1 week after the initiation of re-irrigation.

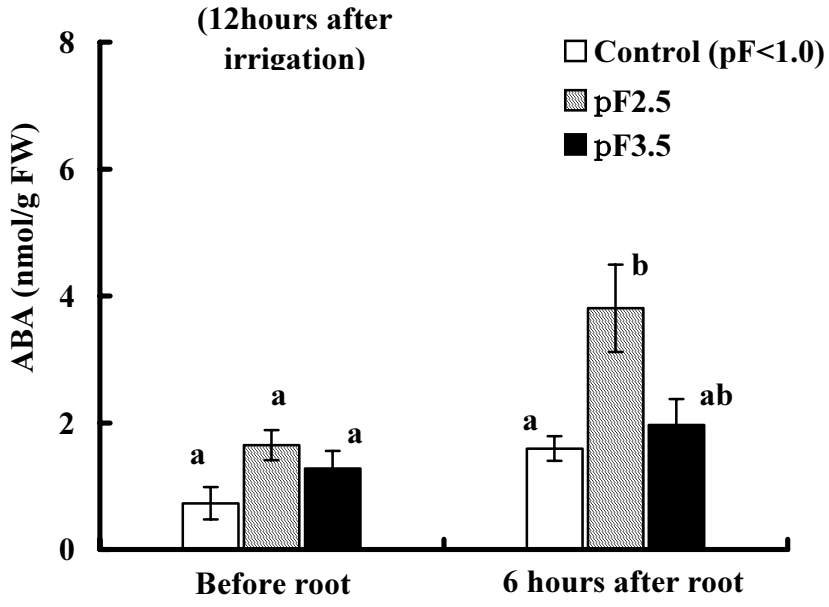


Fig. 2-12 Changes in ABA contents of non-stressed and stress-experienced seedlings of *Juniperus procera* before and after root cooling at 12 hours after the initiation of re-irrigation. Significant differences of the means of each time are indicated by different letters (Scheffe's test, $P<0.05$).

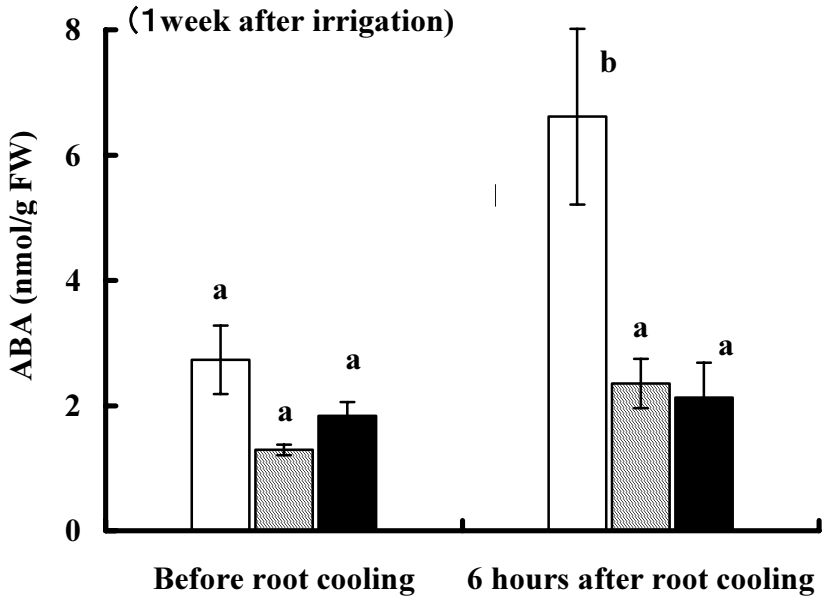


Fig. 2-13 Changes in ABA contents of non-stressed and stress-experienced seedlings of *Juniperus procera* before and after root cooling at 1 week after the initiation of re-irrigation. Significant differences of the means of each time are indicated by different letters (Scheffe's test, $P<0.05$).

3 Ecology of the juniper woodlands of the Asir Mountains

Ken Yoshikawa, Tarik Abbasi, Masaji Saito, Rabea Abdulrahman, Rabah Al Harbi and Fukuju Yamamoto

Introduction

In Abha city, the average rainfall from 1966 to 1974 and from 1987 to 1989 was 655 and 211 mm/year, respectively (Bader and Mounir, 1992), and the relative humidity between 1986 and 1989 was 56%. The annual mean temperature was 14--16°C. In the mountainous areas of the Asir region, the amount of precipitation is relatively high and temperatures are moderate in higher elevations.

Such a semiarid region with no marked seasons of precipitation (Shmida, 1985) will generally support a savanna vegetation with sparse trees and herbs dominated by drought tolerant species of *Acacia*, *Prosopis*, and *Artemisia*. In the Raydah Nature Reserve, a large number of individual trees of *Juniperus procera* grow along the mountain ridge and form nearly pure forests. The existence of the forests is no doubt due to the periodic cover of dense fog derived from ascending air currents along the steep slope of the Wadi Raydah throughout the year.

Dieback of the trees is caused by various environmental stresses, including water deficiency, high and low temperatures, radiation, lack of nutrients, aerial pollutants, and biotic stresses such as insect attacks, over-grazing, and diseases. A number of individuals of *Juniperus procera* died or were showed serious dieback, but the causes of the die-off and dieback of these trees in the Raydah Nature Reserve have remained obscure.

This chapter presents the results of an ecological study aimed at clarifying the structure and dynamics of the *Juniperus procera* forests and the causes of the dieback in the region.

Methods

Study area

The study area is located in the Raydah Nature Reserve near Abha city, the provincial capital of the Asir region. The reserve is on the southwest edge of the Kingdom between 18°11°N and 18°13°N latitude, 42°23°E and 42°25°E longitude, and between 1,580 and 2,830 m elevation (Fig. 3-1). The reserve covers an area of 10.5 km^2 (about 9 km^2 of which is *Juniperus procera* forests) on the upper edge of a steep mountain slope facing southwest. The uppermost, northeastern border of the reserve is on the mountain ridge. Most of the reserve lies within the

watershed of the Wadi Raydah. The average gradient of the slope of the study area is more than 30°.

Experimental plot

Within the study area, a few small valleys and tributaries of the Wadi Raydah form relief on the mountain slope. The juniper trees on the north-facing slope and bottoms of the valleys appear to be more vigorous than those on the south-facing slope and crests. To determine the effects of topography on the growth of junipers, eight experimental plots (20 × 20 m) were established in the Raydah Nature Reserve. Their size and topographic characteristics are shown in Table 3-1.

In each plot, tree height, stem circumferences at about 1 m above ground level, number of stems per tree, sex, and degree of dieback of all junipers were determined. (Fig. 3-2) To determine the degree of dieback, trees were classified into six degrees of damage according to the extent of crown degradation and given scores from 1 (healthy) to 6 (dead). Most of the junipers have stem-harvest traces throughout the study area because the Raydah Nature Reserve was a common forest. The height of man-made wounds were also measured on each tree. Further, the height and stem circumference of other woody species exceeding about 2.5 m tall were determined. The measurements were replicated three times between 1994 and 1999: in December 1994, March 1998 and December 1999.

The location of the trees and stumps in each plot was recorded and their crowns were projected on graph paper.

Biomass

One tree on a crest near Plot 4, which was 5.80 m tall and 18.8 cm in stem diameter showing dieback (4th degree), was cut down. Five trees of *Juniperus procera* were harvested in September near Plots 3 and 4 to measure their biomass. Tree heights, stem diameter at breast height, and crown size were previously measured. The length of living and dead stems and branches were measured. Table 3-2 shows the sizes of the harvested trees.

The sample trees were on average approximately 6.5 m tall and 9 to 30 cm in DBH. Trees 1 and 4 trees had large crowns. Dieback was observed in the canopy of trees 1, 2, and 3; there was no dieback in Tree 4.

The fresh weight of the needles, branches, and the stem parts were weighed. Approximately 500 g of each plant part was sampled and the weight was determined after drying at 80 °C for 48

hours. The total dry weight of each plant part was estimated based on the dry weight values of the sampled parts.

Disks about 1 cm in thickness were removed from the stem at 30 cm above ground level for growth ring analysis.

Distribution

On 29 October 1996, we used a video camera to record the distribution of junipers and the degree of to them during an aerial survey from Bani Malik to Raydah. We surveyed from Jabal Al Hashr to Raydah and Jabal Tallan for three hours, and then surveyed from Jabal Fayfa to Jabal Al Oanar through Jabal Tallan and Jabal Thahran for two hours.

Results and discussion

1. Forest structure

1.1 Species composition

Details of species composition of the juniper forests in the Raydah Nature Reserve are described in Chapter 4.3. Therefore, only a list of species in each experimental plot is shown in Table 3-3.

1.2 Aerial survey

As epidemic die-off never occurs in vegetation without junipers, the information for the distribution of junipers around the Asir and Jizan District is necessary before making plans to protect the forests. An aerial survey with a video camera was carried conducted from Bani Malik to Raydah to observe the distribution of junipers and the degree of damage to them.

Spatial distribution of juniper trees in Fayfa

Since these flights were the first in our experience, it was not always easy to determine our position during the survey. By using a video camera, however, we were able to make a rough distribution map of junipers in Fayfa shown in Fig. 3-3. From Raydah to Fayfa, the junipers grow continuously along the ridge of mountains. Their distribution, however, is restricted to the upper part of the southeast facing slopes above 1,500 m, suggesting that their distribution depends on moisture carried by wind from the Red Sea.

1.3 Tree density

Juniperus procera dominated and formed the forest canopy in all experimental plots, but the density of the trees differed considerably among plots. Table 3-4 shows the density of *Juniperus procera* in each plot. In Plots 1, 3 and 4, the density of *Juniperus procera* exceeded 1,000 individuals/ha, whereas the density in Plots 2, 5, 6, and 7 was less than 700 individuals/ha. In contrast, the density of other woody species including *Dodonaea* angustifolia L.f. was greater in Plots 2 and 5 than in the other two plots facing north.

Tree density and altitude

Fig. 3-4 shows the increase in density of *Juniperus*. *procera* with increasing altitude in the Raydah Nature Reserve.

Effect of slope direction

Tree density was remarkably higher on the north-facing slope plots than on south-facing ones at 2,600 m in altitude, as shown in Fig. 3-5.

1.4 Size of trees

Size difference

Tree height, stem diameter, and number of trunks per tree are shown in Table 3-5. The average values of tree height in Plots 2 and 5 were 5.2 ± 0.7 m and 6.0 ± 0.4 m, respectively, whereas those in Plots 3 and 4 did not exceed 5 m. One tree in Plot 2 was 12 m tall, indicating the potential height of *Juniperus procera*, but about 8 m was about the upper limit of *Juniperus procera* in the Raydah Nature Reserve. Stem diameters in Plots 2 and 5 were twice those in Plots 3 and 4. Stem diameter of *Juniperus procera* in the Raydah Nature Reserve ranged from 2.3 to 61.5 cm. Most other species had a DBH of less than 10 cm.

Frequency distribution

The frequency distributions of trees by tree height and DBH classes are shown in Fig. 3-6. The pattern differed among plots. Trees of various heights occurred in Plots 2 and 3, whereas Plots 4 and 5 showed unimodal frequency distribution of trees with a height of 5 m and 6 m, respectively.

As shown in Fig. 3-6-1, there were few large trees (over 30 cm DBH) in Plots 3 and 4 in comparison with Plots 2 and 5. In Plot 3, the diameters of 54% of the trees of *Juniperus procera*

were less than 8 cm DBH

Small trees - Regeneration

Both Plots 3 and 4 on north-facing slopes have dense forests of uniformly sized trees of *Juniperus procera*, but the proportion of young (small) trees in Plot 3 (Ignore the comments.) was higher than in Plot 4 and in two other plots, indicating active regeneration in Plot 3. In Plot 4, there was no regeneration of *Juniperus procera* because of low light intensity on the forest floor due to the closed canopy of the mature trees. There appeared to be no regeneration of *Juniperus procera* in Plot 5, which contained not only *Juniperus procera* but other species in the second layers of the forest canopy.

Effect of density

Fig. 3-7 shows the correlation between tree height or diameter and the density of the juniper trees. Tree height and diameter are negatively correlated with density, indicating that the size of the junipers decreases with an increase in tree density.

Sex ratio

Fig. 3-8 indicate the number of male and female junipers in each plot. Trees with no reproductive structures are scored as "sex unknown." The sex ratio was greater in Plots 4 and 5 than in Plots 2 and 3. In 1998, the rate of males to females was almost 1:1.

1.5 Growth

Fig. 3-9 shows the height growth of *Juniperus procera* in the five years from 1994 to 1999. Even in trees suffering dieback, there were remarkable increases in height of the main stem.

Fig. 3-10 shows the relationship between annual height and diameter growth in four different plots.

In Plot 3, located on a north slope, an appreciable increase in height of the junipers was recorded. Increase in stem circumference ranged between 0 and 0.5 cm. In Plot 2 on a southern slope, growth was stagnant and about a half of the trees showed dieback. In Plot 4 on a dry ridge, many trees with dieback were observed and growth in apparently healthy trees was negligible. In Plot 5, along a valley, most trees showed relatively active growth and very few trees with dieback were observed. These observations indicate that the dieback of junipers in the Raydah Nature

Reserve is correlated with soil and atmospheric moisture.

1.6 Biomass

Structure

Table 3-6 shows the total dry weight (kg) of four harvested trees of *Juniperus procera*. Dieback was observed in the canopies of Trees 1, 2, and 3, but there was no dieback in the tree 4. The dry weight of the needles of Tree No. 4 was the greatest among the harvested trees. Tree No. 1 had the greatest biomass from non-assimilation organs.

Fig. 3-11 shows biomass diagrams of the four trees of *Juniperus procera*. In Trees 1, 2, and 3, the biomass of the non-assimilation organs in the lower part of the trees was greater at than in the upper parts. Many needles were on the lower part of Trees 1 and 2. Such crown structure was commonly observed in conifers growing in low density forests. In the *Juniperus procera* forest of Raydah, however, dieback affected the structure and distribution of assimilation and non-assimilation organs.

Fig. 3-12 shows the relationship between DBH and needle biomass (left) and the biomass of stems and branches (right). The correlation between DBH and the biomass of the stems and branches was greater than between DBH and needle biomass, indicating an imbalance between assimilation tissues and non-assimilation tissues in the largest tree (No. 1). Such an imbalance was undoubtedly caused by recent dieback. In Tree No. 4, however, the needles were on the upper part. The tree showed no dieback and the stem was rather straight. The data reflect the fact that Tree No. 4 was growing in a humid, dense forest in a valley.

Standing stock

From the relationships between the values of D2H, and the non-assimilation (WC) and assimilation organs (WL) of harvested sample branches, regression formulas were used as follows to estimate WL and WC:

$$\log(WL) = 0.6111 \log(D2H) - 2.5338$$

$$\log(WC) = 0.8578 \log(D2H) - 3.0070$$

Table 3-7 shows that the approximate biomass of assimilation organs, non-assimilation organs, and total biomass is about 0.5, 3-5, and 4-6 ton/ha, respectively. In tropical rainforests with the best conditions for plant growth, biomass has been estimated to be from 250 to 500 ton/ha. In steppe and savanna vegetation, the total biomass ranges from 10 to 15 ton/ha. The biomass of *Pinus*

pumila, a subalpine tree near timberline in Japan, is from 60 to 130 ton/ha. In the Raydah study, the estimated biomass is less than in savannas, indicating that more precise data are needed to know the exact biomass of *Juniperus procera*.

The biomass of the assimilation organs of *Juniperus procera* in Plot 3 was the greatest while in Plot 5 it was the lowest. In Plot 5, however, the total biomass of woody plants was higher because of the presence of other woody species.

The biomass of the non-assimilation organs was greatest in Plot 2, in spite of the opened canopy. The lowest biomass was in Plot 4, where the canopy is relatively closed. These differences are likely due to the differences in tree height between the two plots, which is the result of environmental factors having an effect on the trees in each plot.

1.7 Growth ring analysis

The one tree that was sampled to determine its age had over 280 growth rings, although many false rings were included in the count. Still, the approximate age of the tree may be over 200 years (Table 3-8).

1.8 Regeneration

For sustainable conservation management, knowledge of the regeneration system in juniper forests under natural conditions is important. A preliminary survey was undertaken on the dynamics of juniper seedlings in several permanent experimental plots.

Thirty-nine seedlings were found and numbered near Plot 8. The sizes of the seedlings were measured. The relationships between stem diameter at ground level and height showed a positive correlation (Fig. 3-13).

To evaluate the grazing pressure, we established two fenced experimental plots to prevent grazing by livestock. The quality of the fence was insufficient to prevent entry by cows and goats and it will be necessary to enforce the enclosing fences before meaningful results can be obtained.

2 Forest dynamics

2.1 Number of stems and wounds

Within the reserve, local inhabitants harvested matured trees of *Juniperus procera* until 1991 when the Raydah Nature Reserve was established, but they frequently pastured livestock, which

grazed both grasses and seedlings of *Juniperus procera*, within the reserve.

Because the Raydah Nature Reserve was a common forest, most of trees of *Juniperus procera* in the study area showed signs of stem harvest. Table 3-9 shows the numbers and percentage of wounded trees and the heights of wounds. In Plot 2, 12 stumps remained in the *Juniperus procera* forest with 17 standing trees in a 20 × 20 m area. Wounds from cutting were observed in 80 to 90% of the trees.

Fig. 3-14 shows the frequency distributions of wounded trees classed of wound height. Most of wounds were made near the base of the trunk and were not above 1.3 m from the ground, suggesting that the inhabitants tried to use timber effectively, not only for building material but also for firewood.

Fig. 3-15 shows the frequency distributions of trees classed by stem number. Although over one half of the trees in all plots had a single stem, some of them had more than five stems per tree. The average number of stems per tree in all plots ranged from 1.6 to 2.3 (Table 3-9). However, the distribution patterns were not significantly different among plots (α=0.05) (Table 3-10).

2.2 Spatial distributions of *Juniperus procera*

Fig. 3-16 shows the spatial distribution patterns of standing trees and stumps of *Juniperus procera*, and other woody species in each plot. To analyze the aggregation pattern of *Juniperus procera*, the mean crowding (m*) index (Lloyd 1967) and mean density (m) were calculated from those figures.

Explanation of the mean crowding

The mean crowding is defined as the mean number of other individuals per individual in the same quadrat and is shown by:

$$m^* = \frac{\sum_{j=1}^{Q} x_j (x_j - 1)}{\sum_{j=1}^{Q} x_j}$$

where x j is the number of individuals in the jth quadrat and Q the total number of quadrats contained in the population.

Iwao (1972) proposed the analytical “m*-m method” for analyzing the aggregation patterns of

biological populations on the basis of the m*-m relationships. The m*-m method includes two different methods: 1) the unit-size m*-m method to analyze spatial patterns by repeatedly changing the quadrat size; and 2) the series m*-m method using linear regression between m* and m of several populations for each successive quadrat size. The more detailed picture of the spatial structure of the population is obtainable by the combined use of both the unit-size and the series relations of m* on m (Iwao, 1972).

In the series of m*-m relations, Iwao (1971) found that in a wide variety of situations, including both theoretical and biological distributions, the mean crowding (m*) is linearly related with the mean density (m) over a range of different densities. The relation is shown by

$$m^* = \alpha + \beta m$$

where α is the intercept on m*-axis and β is the regression coefficient.

When the basic component is a single individual, the regression passes through the original and has a slope p = m*/m. If the basic component is not an individual but a colony, the intercept α always takes a positive value, indicating size and colony.

Then the α shows whether a single individual or a positive or negative association of individuals is the basic component of the distribution, and β suggests how such basic components distribute themselves over the space. Iwao (1971) presented the analytical method of regression of m*-m relations for detecting aggregation patterns. According to this method, the values of α and β in various distribution models are as follows:

Random distribution: $\alpha = 0, \beta = 1$

Contagious distribution:

the Poisson distribution of colonies whose mean size remains approximately constant over a range of different densities, $\alpha > 0, \beta = 1$

aggregated distributions of independent individuals that fit to the negative binomal series with a common k, $\alpha = 0, \beta > 1$

aggregated distribution of colonies as a mosaic of different density of the area, $\alpha > 0, \beta > 1$

Uniform distributions:

completely uniform (regular) distributions,

when mean density <1, $\alpha = 0, \beta = 0$

when mean density >1, $\alpha = -1, \beta = 0$

positive binomial distribution (every quadrat has the same probability being occupied by an individual but the capacity of it is limited), $\alpha = 0, \beta < 0$

From these considerations, we may conclude that α is equal to zero when a single individual is the basic component of the distribution, and greater or less than zero when there is positive or negative association between individuals, and that β is less than, equal to, or greater than unity in the uniform, random, or aggregative distribution pattern of the basic components. The former is called the "index of basic congregation," and the latter, "density-contagiousness coefficient."

Living trees

Fig. 3-17 shows the unit-size m*-m relations of living trees of *Juniperus procera* by changing quadrat size successively from 1.25×1.25 m to 20×10 m. The inclination lines of the m*-m relationship of most of the plots, except Plot 5, were nearly on the Poisson line (slope = unity), suggesting the random distribution of living trees of *Juniperus procera*.

From these data, series m*-m relationships were calculated for each unit size. Correlation coefficients of each regression line were higher than 0.96, except in the 1.25 × 1.25 m unit. Fig. 3-18 shows changes in the values of intercepts on the m*-axis (α) and inclinations (β = regression coefficients) with the size of the units in these regression lines. The values of α of the living trees of *Juniperus procera* changed from –0.2 to –0.3 and the β values were almost equal to unity. These results indicate that the spatial distributions of the living trees of *Juniperus procera* have a tendency to change from the contagious distribution at the smallest unit size (1.25 × 1.25 m) to a random or close to completely uniform distribution of an individual tree with an increase in unit size.

Stumps

Fig. 3-19 shows the m*-m relations of the stumps in four different plots, indicating uniform distributions in all but in Plot Ns. The random distribution of stumps appeared in Plot Ns on a unit of a loose colony of about 1.25 × 2.5 m might be caused by aggregative appearance of three stumps in the center of the plot (Fig. 3-16).

The changes in the values of α and β in series m*-m relations of the stumps are shown in Fig. 3-20. The stumps indicated approximate positive binomial distribution when the unit size is smaller than 1.25 × 2.5 m and complete uniformity when the unit size is 2.5 × 2.5 m. With an increase in unit size greater than 2.5 × 2.5 m, the spatial distribution of the stumps changed from random individuals to colonies. Hence, the stumps indicate a uniform distribution under a certain unit size and in the results from the m*-m relationships through a successive change in unit size.

Total junipers

The spatial distribution of *Juniperus procera* about 10 years ago could be estimated by analyzing all trees, including both standing trees and stumps. Fig. 3-20 shows the unit-size m*-m relationships of all *Juniperus procera* with successive changes in quadrat size. It suggests random distributions, which are similar to those for living trees described above (Figs. 4-17, 4-18).

3 Dieback

The extent of dieback damage to forests is related to the physical and physiological factors imposing stress on individual trees. The present structure of the forests, including changes in forest tree density, species diversity, and shapes of trees, is therefore the result of these effects on both the forest and on individual trees.

3.1 D-H relation

Fig. 3-22 shows correlation between tree heights and DBH for all trees of *Juniperus procera*, including both undamaged and damaged individuals in each plot. In all plots, the maximum height to diameter showed an asymptotic relationship, indicated by dashed lines in the figures. These lines reflect the slight differences in maximum tree heights detected among plots, namely 6.5, 8, 8, and 8.5 m in Plots 4, 3, 5, and 2, respectively. Except in Plot 4, trees larger than 10 cm in DBH reached the upper canopy of the forest under favorable conditions.

3.2 Tree size and degree of damage

Tree size

In Fig. 3-22, damaged trees represented by open circles show the different relationships between DBH and tree height from those of undamaged trees shown by solid circles. Dashes indicate the height of damaged stems on undamaged crowns. Vertical lines connecting the dashes and open circles signify stems with dieback. Most of the dashes were near or above the asymptotic line in each plot, indicating that dieback occurred on fully grown trees.

Frequency distributions of degree of damage showed different mode classes among three diameter classes (Fig. 3-23). Trees with a DBH of less than 10 cm had a mode at 3rd damage degree, whereas it became 4th and 5th damage degrees in lager diameter classes, which were 10-20 and larger than 20 cm classes, respectively. Small trees with crowns below the canopy also suffered environmental stress(es) inducing dieback. It appears from Fig. 3-23 that dieback damage

on an individual tree becomes severe as trees become larger.

Shape of trees

Fig. 3-24 shows a schematic representation of a damaged tree crown.

Fig. 3-25-1 shows the relationship between the heights of dead (HD) or living (HL) crowns and the stem lengths of dead crowns in the four plots. There was no clear correlation between tree height and stem length of dead crowns in all plots.

In Plot 3, however, trees can be separated into two groups (Fig. 3-25-2). One, tentatively called Group 1, includes relatively small trees having a high correlation between the height and stem length of dead crowns; another (Group 2) includes large trees (> 4 m) showing no correlation between the height and stem length of dead crowns. In Group 1, the height of the living crowns was nearly the same for all trees (Fig. 3-25-2, lower), whereas the heights of the trees differed in Group 2. These observations imply that dieback of the trees in the Group 1 occurred recently and extended from the apex to an almost equal height above ground level. Such symptoms might be the result of environmental stresses, including serious drought.

In Group 2, however, the stems of the dead crowns were comparatively short, although the trees were taller than those in Group 1. Within this group, most of the apical parts of the dead crowns were broken and lost. These observations suggest that dieback in Group 2 occurred many years ago. The indistinct relationship between the heights of living or dead crowns and the stem lengths of dead crowns in this group might be concerned with the recovery of height growth and shedding of dead parts for a long period after dieback occurs.

Relationships similar to those described above also were found in trees with dieback in Plot 4, showing a slight correlation between heights and length of the stem in dead crowns (Fig. 3-25-3). A similar relationship was not observed in Plot 2 (Fig. 3-25-4). These differences might be due to differences in the structure of forest canopies in the plots. The forest canopy in Plots 3 and 4 were closed, whereas that in Plot 2 was not.

3.3 Topographical effects

Among plots

The frequency distributions of the damaged trees in six damage classes of each plot are shown in Fig. 3-26 for 1994 and 1998. Most trees in Plots 2, 3, and 4 showed serious dieback, whereas trees in Plot 5 were rather healthy. Both the distribution patterns and the mode classes differed

considerably among plots.

Table 3-11 shows the average percent of damaged trees. About 10 to 80% of the trees of *J. procera* showed serious dieback. In Plot 2, located on a south-facing slope, 77% of 17 trees had crowns with dieback. About half of the trees in Plots 3 and 4 also showed dieback, but only a 10% of the trees in Plot 5 had dead crowns.

As a result, both the mean index of degree of damage to the crowns and the percentages of damaged trees in a plot were relatively lower in Plot 5, which is located in a small valley, than in the other three plots located on slopes.

Several trees in Plots 2 and 5 had damaged stems exceeding 6 m long in their undamaged crowns.

The high degree of tree damage in Plot 2 implies that the high temperatures and serious water deficits occurring on south-facing slopes might cause dieback in *Juniperus procera*.

Tree density

As shown in Fig. 3-27, the mean length of damaged crowns was negatively correlated with the tree density of each plot. The decrease of damaged crown length with tree density indicated the increase of stresses in a sparse forest, which induced dieback. The results suggest that the low density of trees on south-facing slopes is the result of severe environmental factors, which occasionally result in the die-off of individual trees

Degree of damage

The relationship between the percentage of damaged trees and the average degree of damage in each plot is shown in Fig. 3-28. The average degree of damage increased with an increase in the percentage of damaged trees. Fig. 3-29 shows the relationship between the percentage of damaged trees and H (D), showing no correlation between the two values. There was a high correlation between H (L) and H (D), however (Fig. 3-30).

The proportion of the length of stems in dead crowns to the height of the tree is shown in Table 3-11. Both the length of the stems in dead crowns and their proportions increased with an increase in average tree height.

Tree size

Fig. 3-31 indicates the relationships between the degree of damage and H (L) corresponding

to each degree. The trees in Plot 3 were shorter than the trees in other plots, indicating that dieback in Plot 3 occurred recently in comparison with other plots.

Table 3-1. Size and topographical characteristics of the experimental plots

Plot No.	Area (m^2)	Altitude (m)	Direction	(°)	Gradient (°)	Location latitude	Location longitude	Establishment
1	400	2825	W	256.5	5.5	18 ° 12'29" N	42 ° 24'57" E	1999
2	400	2650	SW	216.0	34.5	18 ° 12'04" N	42 ° 24'58" E	1994
3	400	2620	NW	326.5	32.0	18 ° 12'01" N	42 ° 24'61" E	1994
4	400	2460	NW	308.5	28.5	18 ° 11'82" N	42 ° 24'49" E	1994
5	400	2415	W	257.5	27.0	18 ° 12'83" N	42 ° 24'44" E	1994
6	400	2245	NW	328.0	39.0	18 ° 11'76" N	42 ° 24'06" E	1998
7	400	2110	NW	307.5	36.0	18 ° 11'66" N	42 ° 23'92" E	1999
8	400	2420	-	-	-	-		2000
B	400	-	-	-	-	-		1999
JT	400	-						1999

B: Blasma; JT: Jabal Thahran

Table 3-2. Tree heights, stem diameters, crown sizes of five harvested *Juniperus procera*

No.	Heights m	Stem diameters cm	Crown sizes (DW-RT-UP-LF*) m	Area m^2
1	6.45	28.50	3.20-3.60-1.80-2.90	25.52
2	5.60	9.00	2.30-1.90-0.85-1.10	7.42
3	5.86	8.75	1.90-2.75-1.30-0.10	7.16
4	7.96	14.60	3.20-2.90-1.50-2.40	19.56
5	2.80	10.00	1.50-1.10-1.20-0.84	4.11

*DW: downward; RT: right side; UP: upward; LF: left side
(The lines drawn by commentator have no mean. So it can ignore.)

Table 3-3. Species composition of each plot (no. of individuals/400m2)

Plot No.	1	2	3	4	5	6	7	8	B	T	JT
Juniper / mature	67	17	62	43	18	25	12		129		58
juniper / seedling	50	0	14	1	6	4	45		30		0
Dodonea	28	12	5	3	11	40	17		6		3
Erica									16		
Nuxia congesta		2									
Acacia				1	1						4
Olea				1	1						
Jasminum					3						
Celtis					3						
Pyracansus						8					
Triple						7					
Teclea							3				
Genus1									2		
Genus2						2			1		
Genus3						21					23
Genus4					6		12				

Table 3-4. Tree density (no./ha) in each plot

Plot no.	Number of trees			Tree density (no./ha)		
	Juniper		Others	Juniper	Others	Total
	Mature	Seedling				
1	67	50	28	1675	700	2375
2	17	0	14	425	350	775
3	62	14	5	1550	125	1675
4	43	1	5	1075	125	1200
5	18	6	25	450	625	1075
6	25	4	78	625	1950	2575
7	12	45	32	300	800	1100
8	-	-	-	-	-	-
B	129	30	25	3225	625	3850
T	-	-	-	-	-	-
JT	58	0	30	1450	750	2200

Table 3-5. Tree heights, stem diameters, and number of trunks per tree

Plot no.	Diameter at breast height (cm) Mean±S.D. (min. - max.)	Height (m) Mean±S.D. (min. - max.)	Number of trunk
1	9.8± 8.9 (2.6− 52.8)	4.78± 1.35 (2.60− 7.77)	±
2	23.7± 18.5 (4.0− 57.8)	5.07± 1.98 (1.85− 9.12)	2.06± 0.28
3	12.9± 9.8 (2.7− 51.6)	4.72± 1.85 (1.49− 8.88)	1.84± 0.17
4	11.7± 7.4 (2.3− 32.2)	4.04± 1.19 (2.11− 6.39)	2.33± 0.27
5	22.3± 13.4 (6.8− 56.1)	6.24± 1.89 (1.04− 8.25)	1.56± 0.16
6	21.0± 13.6 (5.6− 57.0)	4.01± 0.78 (2.09− 5.00)	±
7	15.8± 15.9 (2.4− 61.5)	3.29± 2.21 (0.46− 7.50)	±

Table 3-6. Dry weight (kg) of harvested *Juniperus procera*

No.	Needle	Stem & Branch	Ratio*
1	6.89	153.12	22.22
2	3.61	23.58	6.53
3	4.55	33.04	7.26
4	12.86	56.71	4.41

*: non-assimilation organ/assimilation organ

Table 3-7. Estimates of assimilation and non-assimilation organs (t/ha)

Plot No.	Assimilation organ	Non-assimilation organ	Total
2	0.53	5.15	5.68
3	0.68	4.86	5.54
4	0.53	3.04	3.57
5	0.44	3.83	4.27

Table 3-8. Estimated age of the harvested trees

No.	Estimated age (years)
1	82
2	98
3	107
4	62
5	66

Table 3-9. Numbers and percentages of wounded trees and the heights of wounds

Plot No.	Wounded trees %	Height of wounds Mean±SE (cm)	Number of trunks /tree	Number of stumps*
2	88.2	14 ± 5.8a	2.1 ± 0.3c	12 (17)
3	78.9	21.4 ± 4.3a	1.8 ± .2c	8 (57)
4	77.5	33.5 ± 6.4ab	2.3 ± 0.3c	20 (40)
5	88.9	46.3 ± 9.4b	1.6 ± 0.2c	4 (18)

a,b,c: not significantly different with 5% level (t test)
*: number of standing trees in parentheses

Table 3-10. Statistical result of kai-square test on wound height or stem number among plots

NS: Number of stems

H(W)	Plot 3	Plot 4	Plot 2	Plot 5
Plot 3		0.120	0.495	0.381
Plot 4	0.110		0.607	0.084
Plot 2	0.372	0.062		0.124
Plot 5	0.010	0.271	0.010	

Table 3-11. Extent of die-back damage on *Juniperus procera* forests

Plot no.	Damage degree indices	No. of damaged trees		Damaged crowns			
				Height (m)	Length (m)		
	Ave.±S.E.	No.	%	Ave.±S.E. (min. - max.)	Ave.[1)] (min. - max.)		% [2)]
3	3.68 ±0.13	29	50.9	3.58 ±0.28 (1.30 −7.90)	0.75	(0.00 −1.85)	24.4
4	4.16 ±0.15	23	57.5	5.06 ±0.21 (2.85 −6.85)	0.88	(0.40 −2.15)	15.5
2	4.31 ±0.21	13	76.5	7.28 ±0.60 (4.90 −11.50)	1.96	(0.30 −6.10)	31.6
5	2.33 ±0.29	2	11.1	8.25 ±1.58 (3.50 −10.00)	3.68	(0.85 −6.50)	37.1

1) (height of damaged crown) - (height of living crown)

2) (length of dead stem)/(height of damaged crown) x 100

(Commentator can not find out the place of “1)” and “2)”. Change the size of these words in the table.)

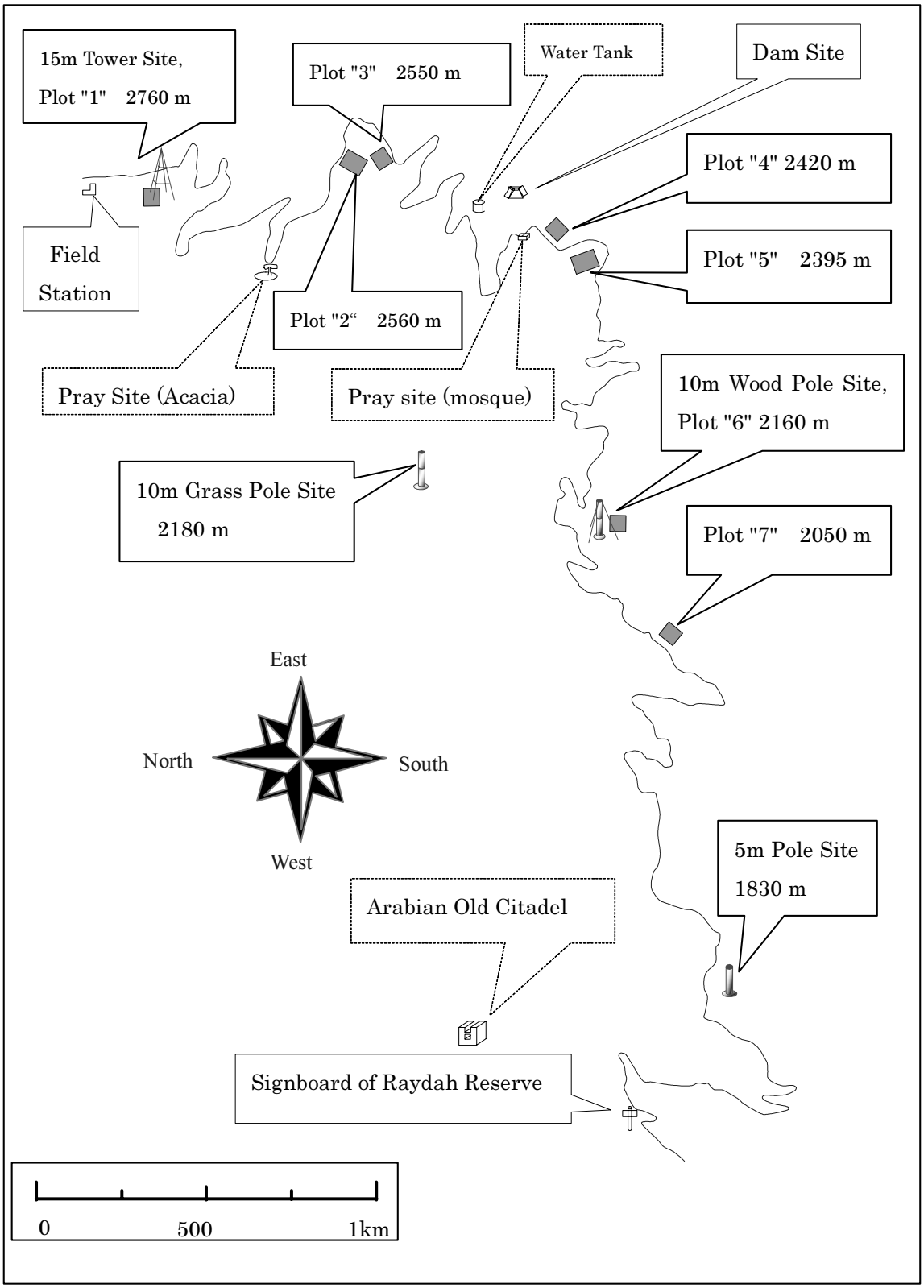


Fig. 3-1. Location of the experimental plots established in the Raydah Nature Reserve

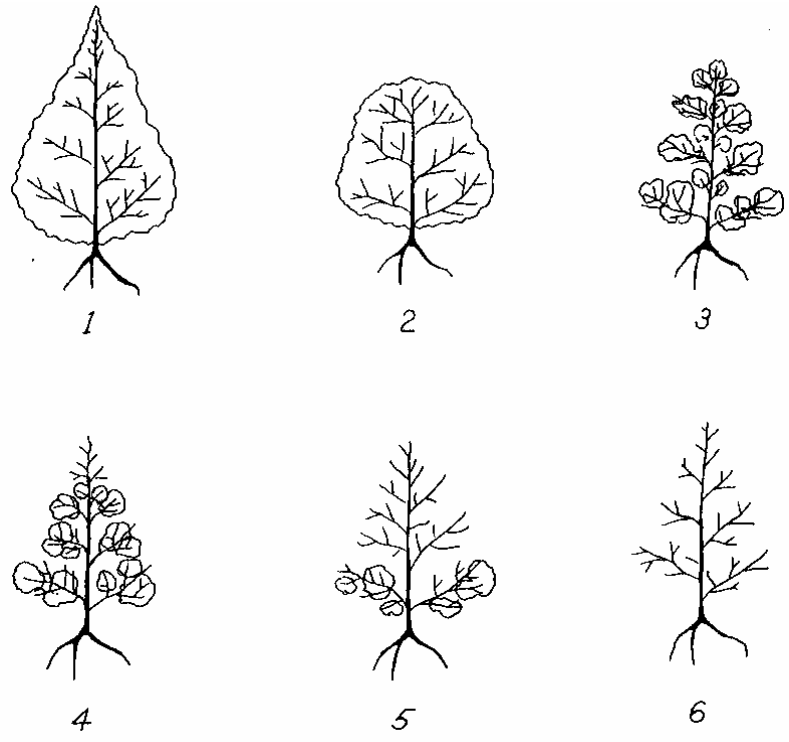


Fig. 3-2. Diagrams of six different damage classes of *Juniperus procera*

Fig. 3-3. Spatial distribution of juniper forest in the Asir region

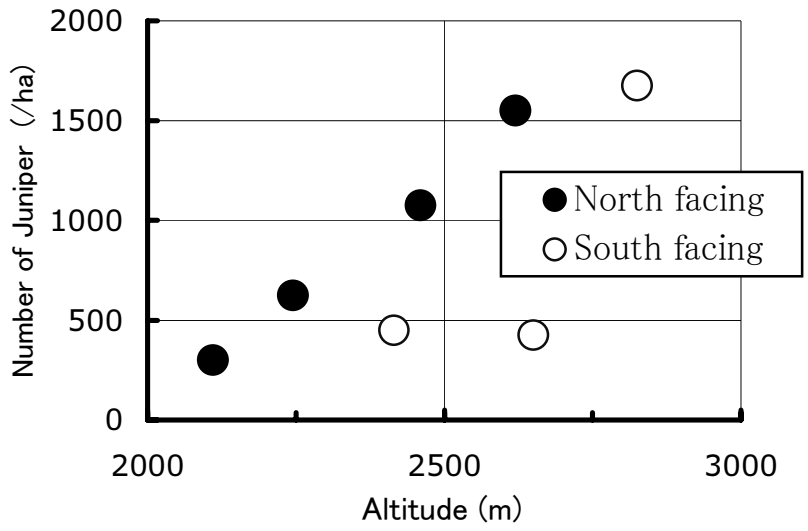


Fig. 3-4. Changes in density of *Juniperus procera* with altitude in Raydah Nature Reserve

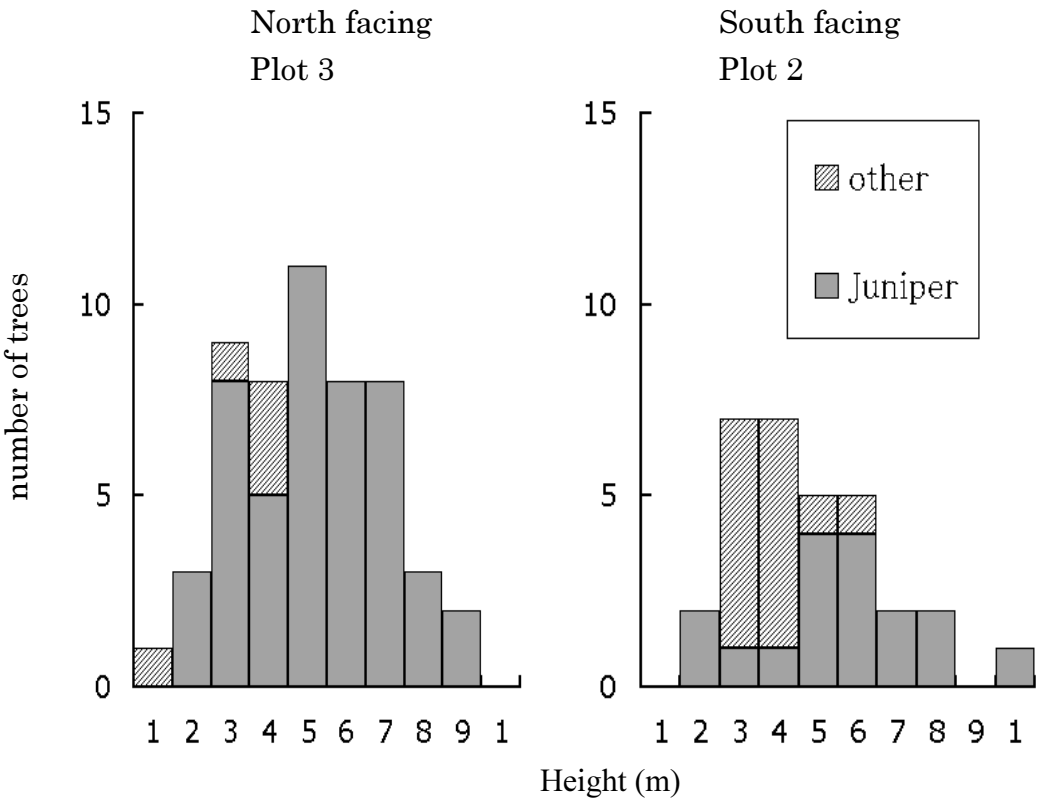


Fig. 3-5. Frequency distribution of tree height in north and south facing plots at a height of 2,600 m

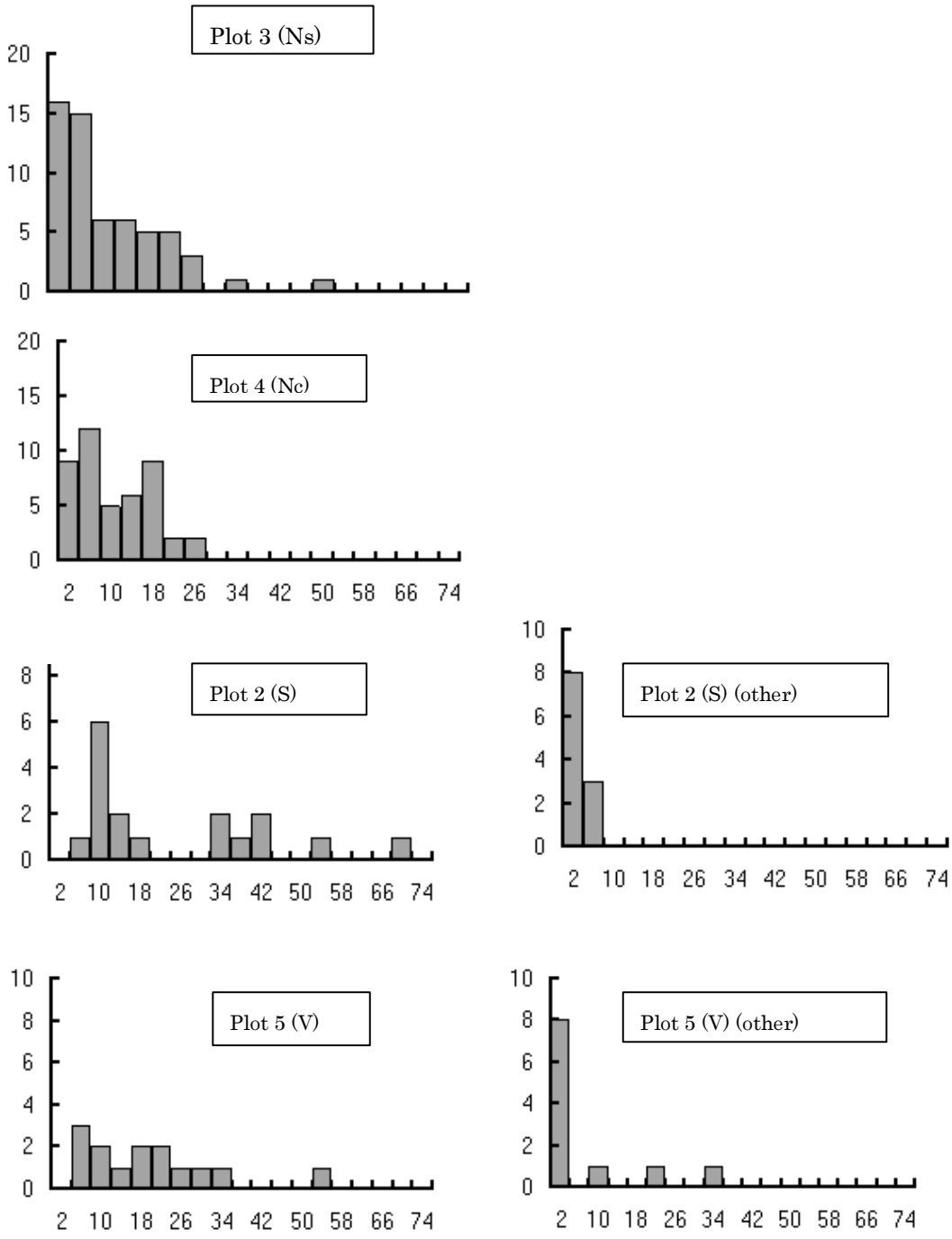


Fig. 3-6-1. Frequency distributions of tree numbers in tree DBH classes in each plot

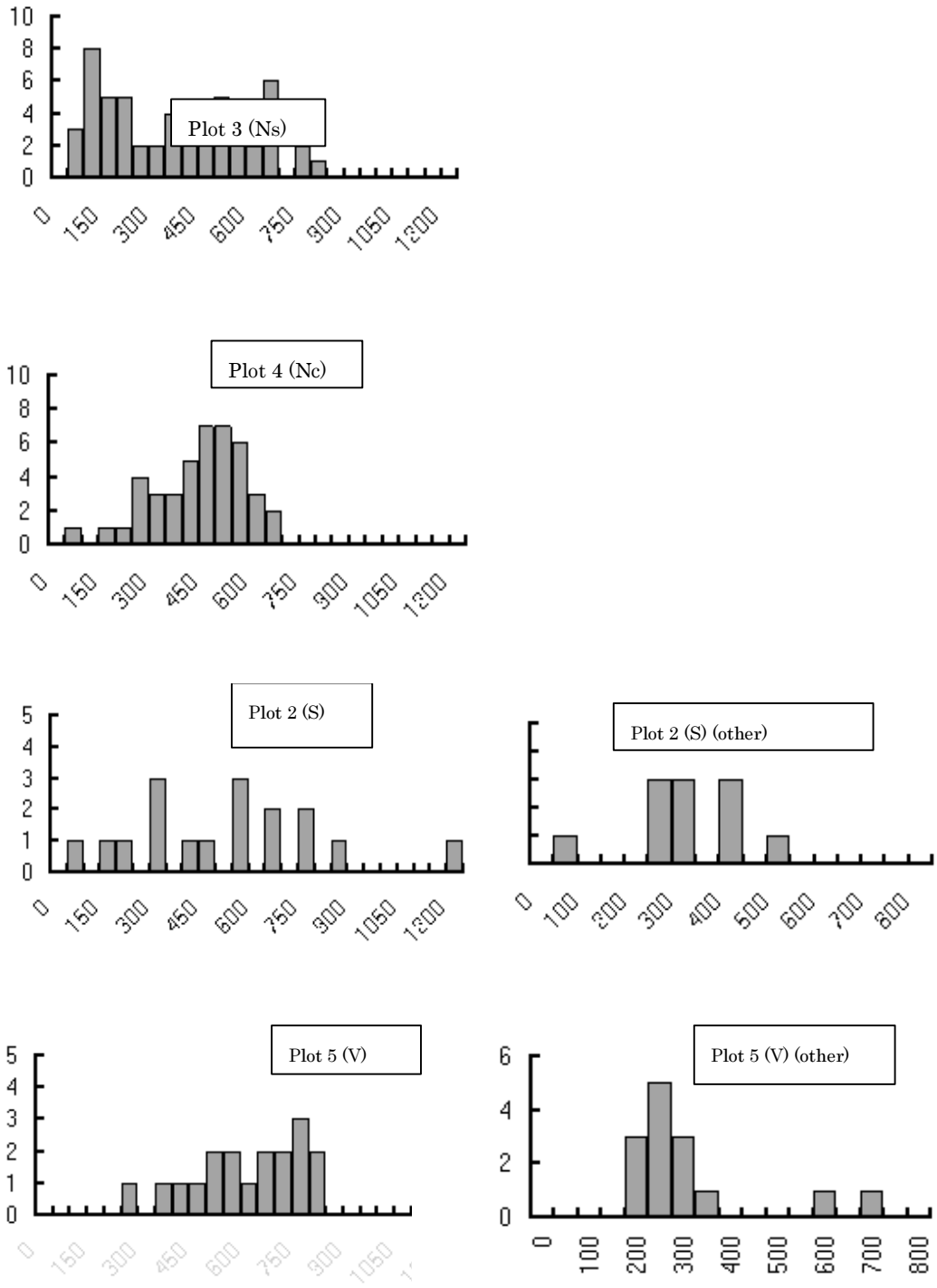


Fig. 3-6-2. Frequency distributions of tree numbers in tree height classes in each plot

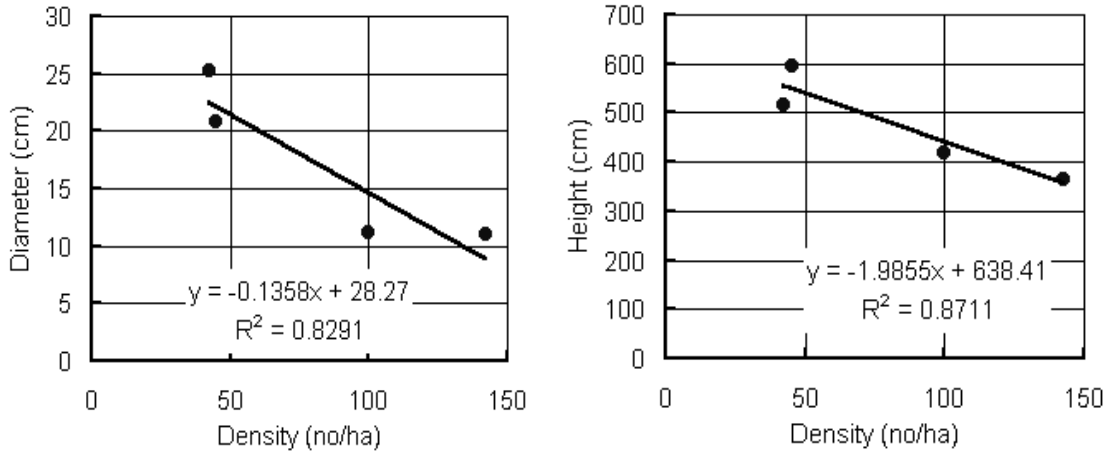


Fig. 3-7. Correlations between tree heights or diameters and density of *Juniperus procera*

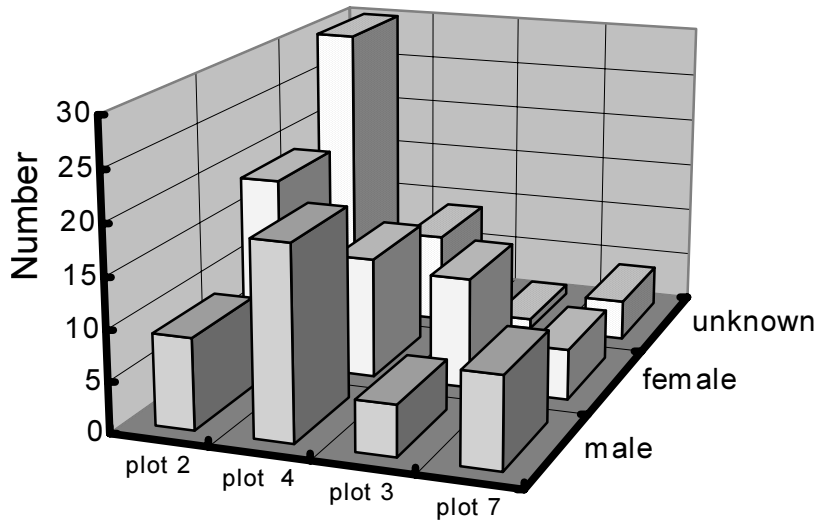


Fig. 3-8. Number of male and female trees in each plot
Trees having no flower bud are indicated as "unknown"

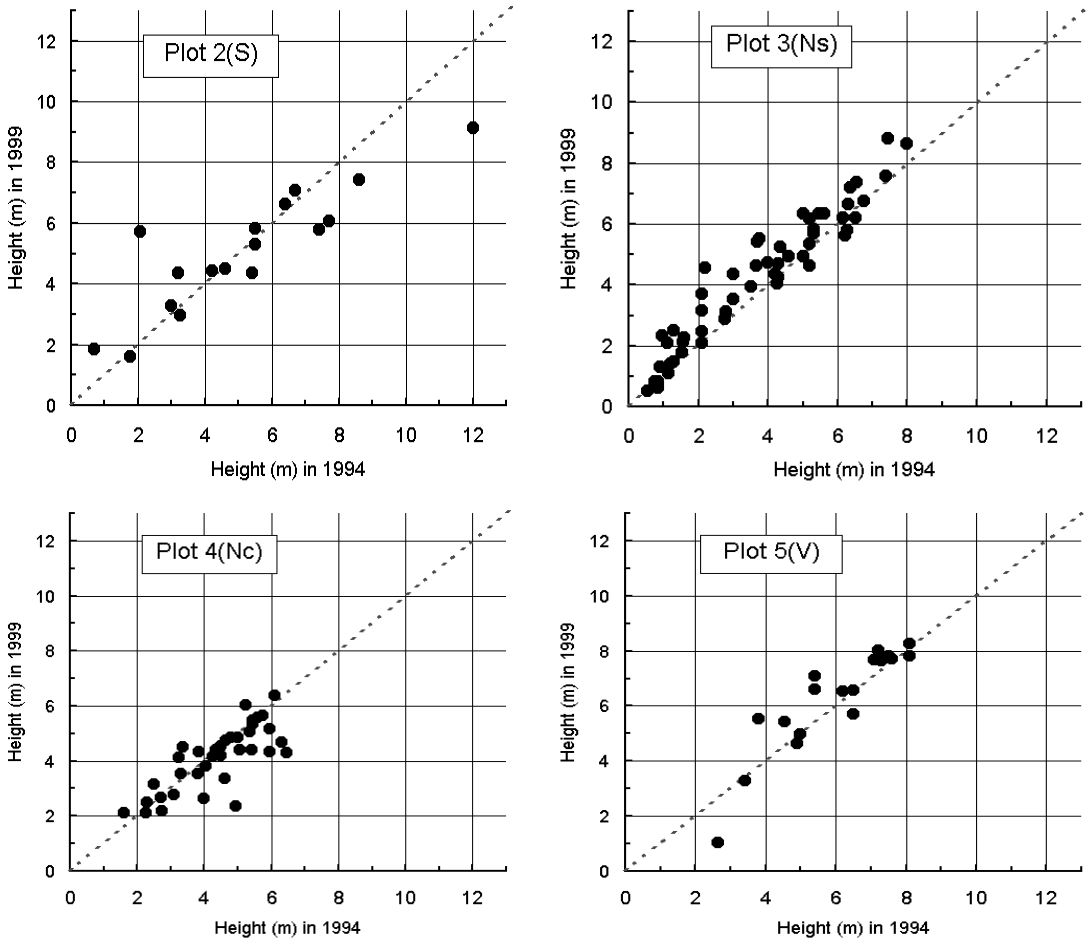


Fig. 3-9. Relationships of the height of *Juniperus procera* between 1994 and 1999

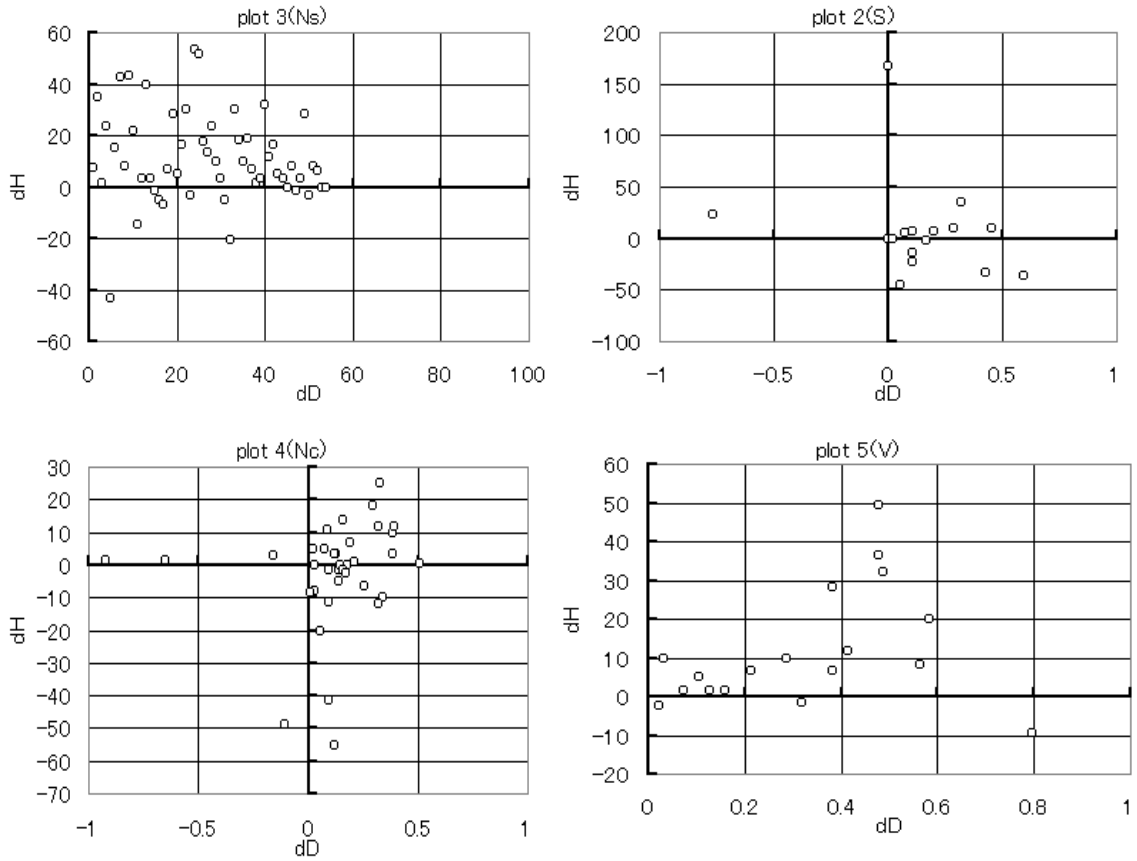


Fig. 3-10. Relationships between annual height growth and annual diameter growth in four different plots

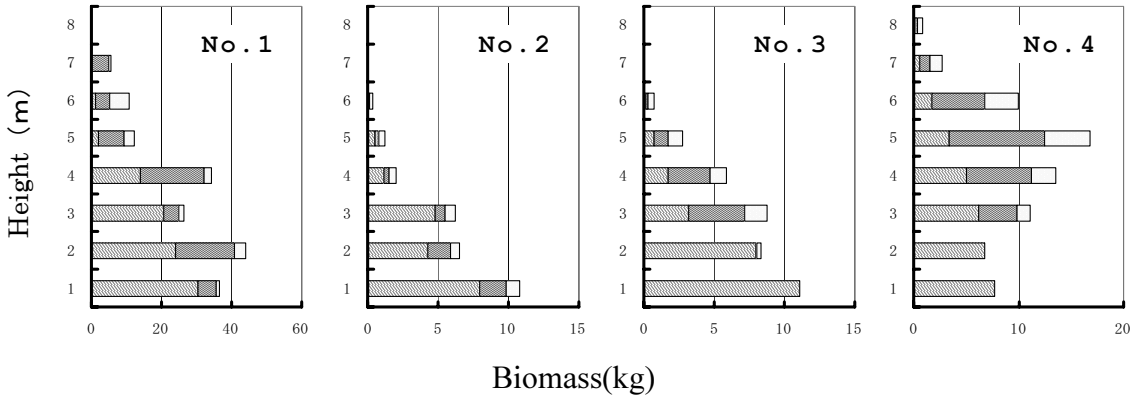


Fig. 3-11. Production structure diagrams of four *Juniperus procera*

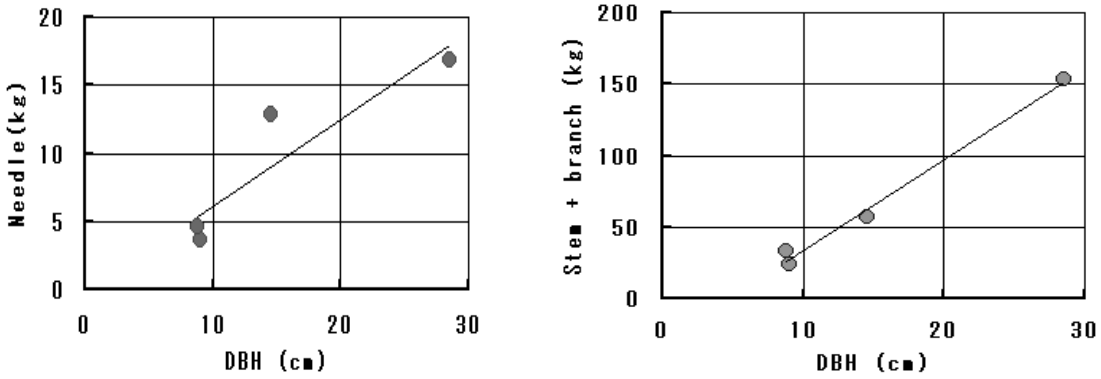


Fig. 3-12. Relationship between DBH and needle biomass or the biomass of stems and branches

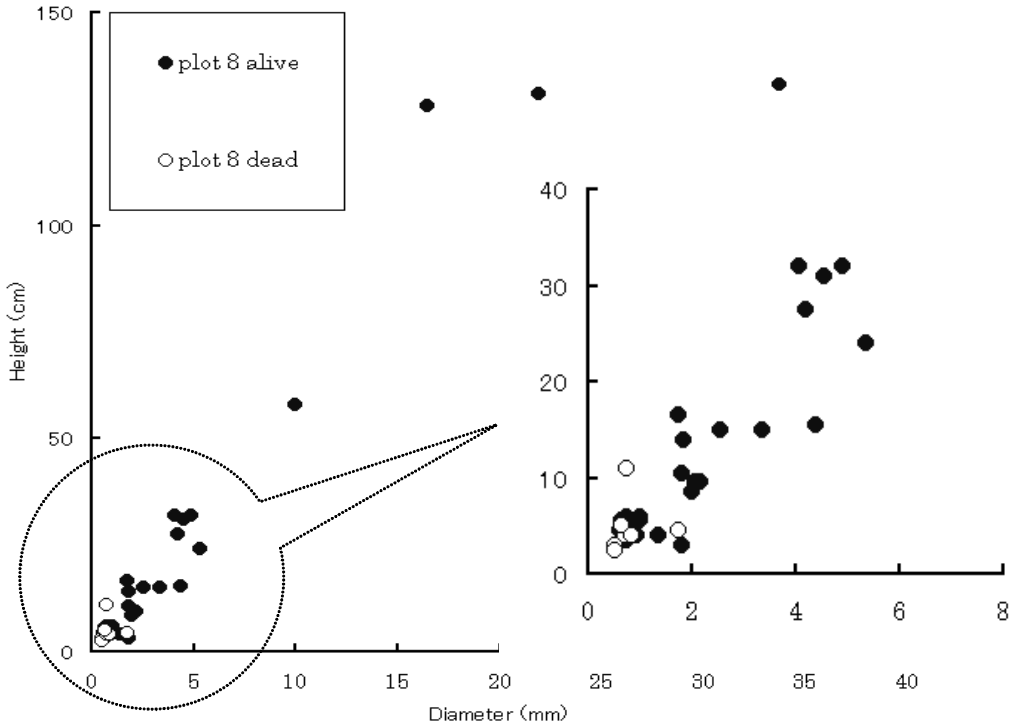


Fig. 3-13. Relationships between diameter and height of seedlings of *Juniperus procera* in Plot 8

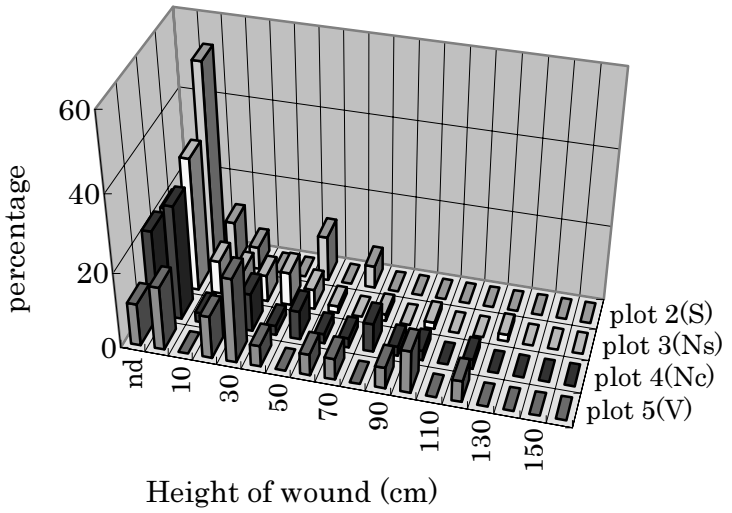


Fig. 3-14. Frequency distributions of wounded trees in the class of wound heights
Percentage of tree numbers in height of wound

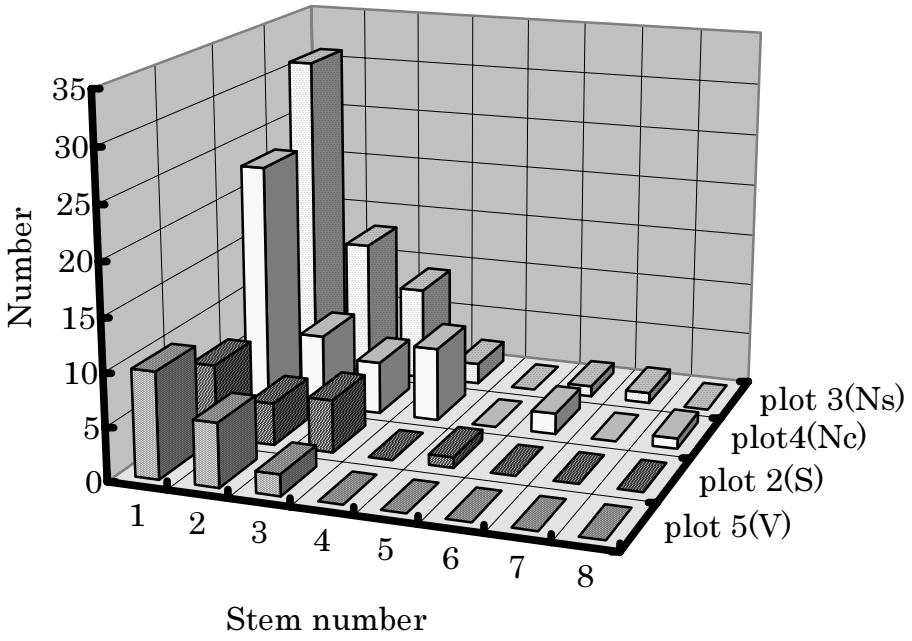


Fig. 3-15. Frequency distributions of tree numbers in stem number class

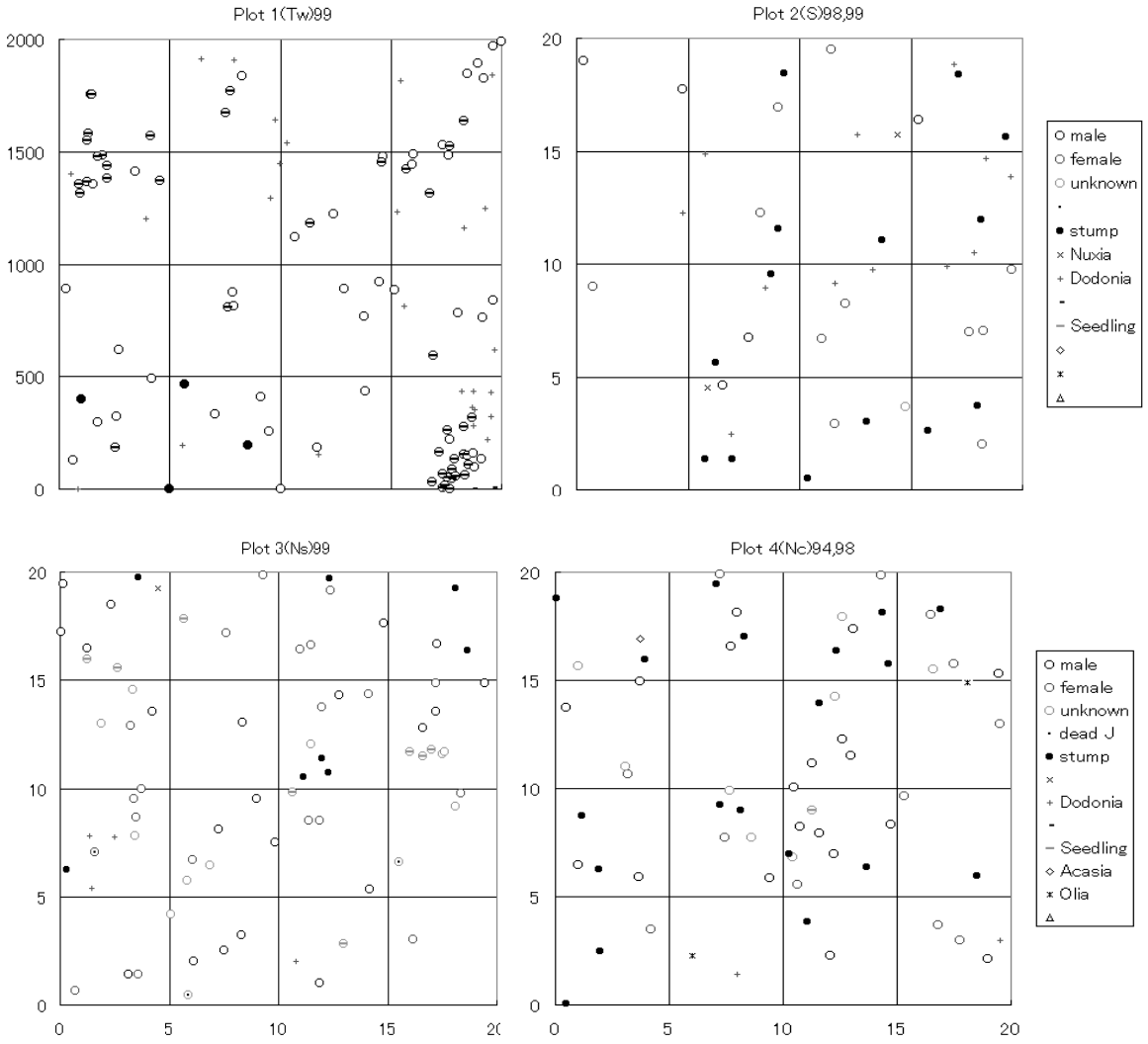


Fig. 3-16-1. Spatial distribution of juniper trees in each experimental plot

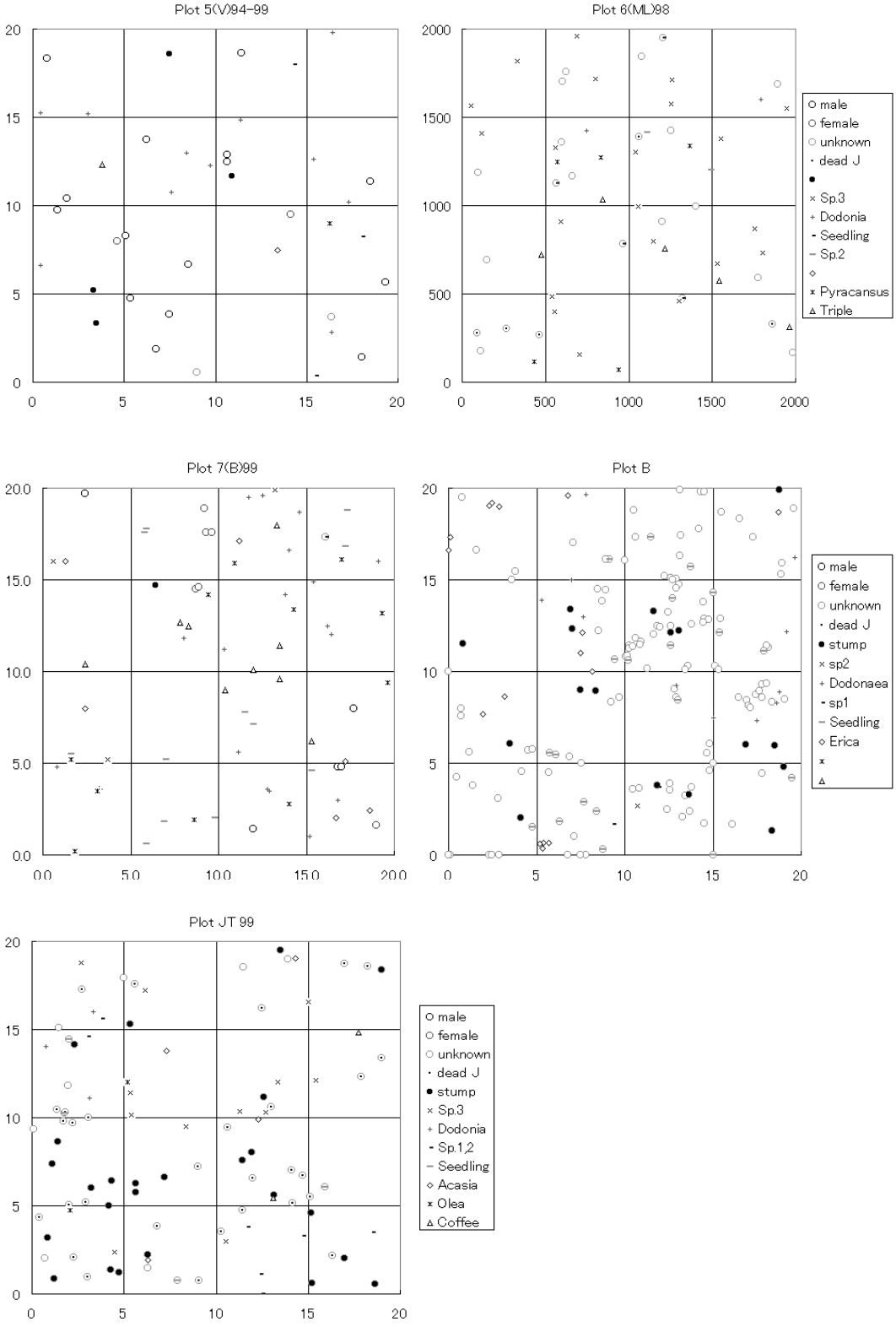


Fig. 3-16-2. Spatial distribution of
trees of *Juniperus procera* in each experimental plot

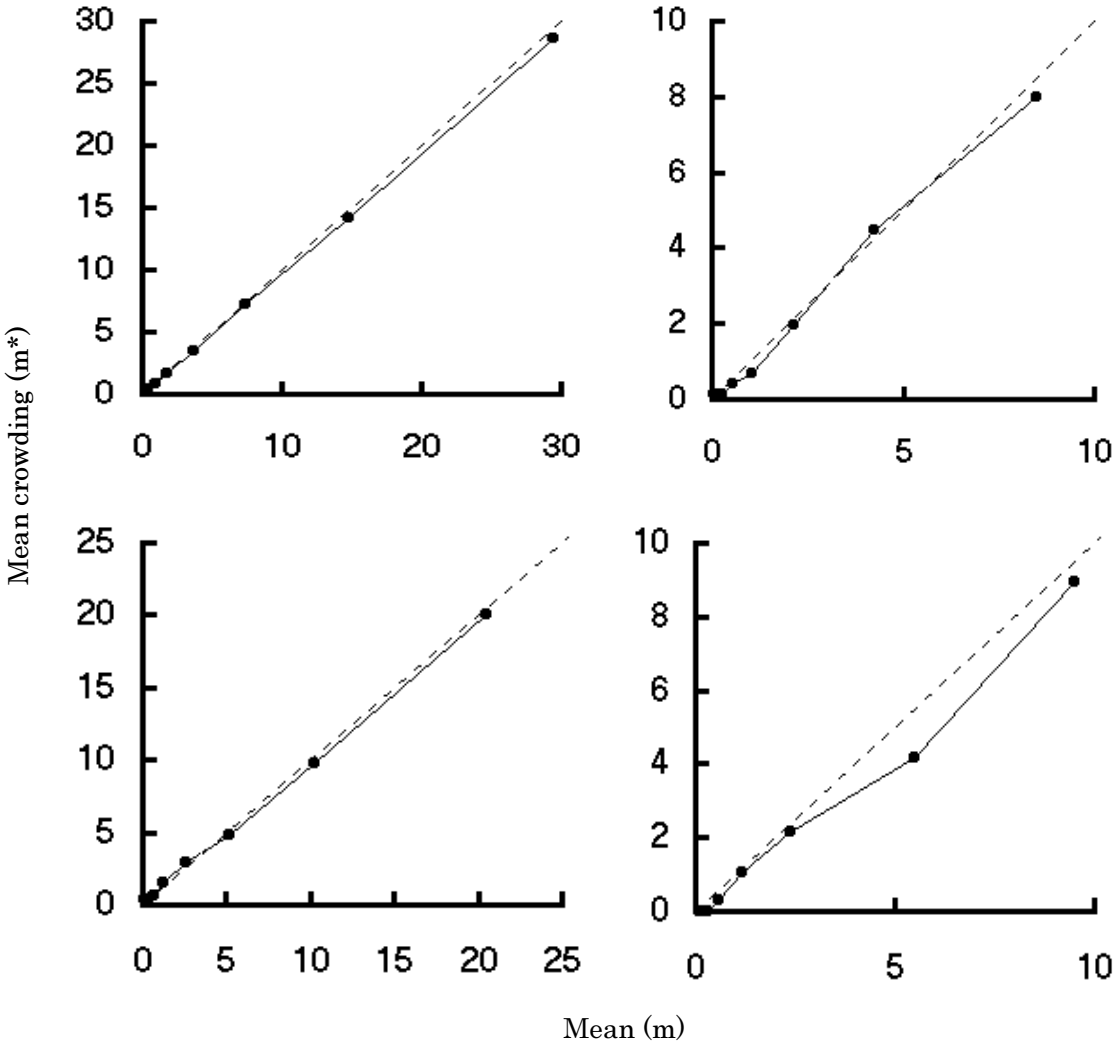


Fig. 3-17. The unit-size m*-m relations of living *Juniperus procera* by changing quadrant size

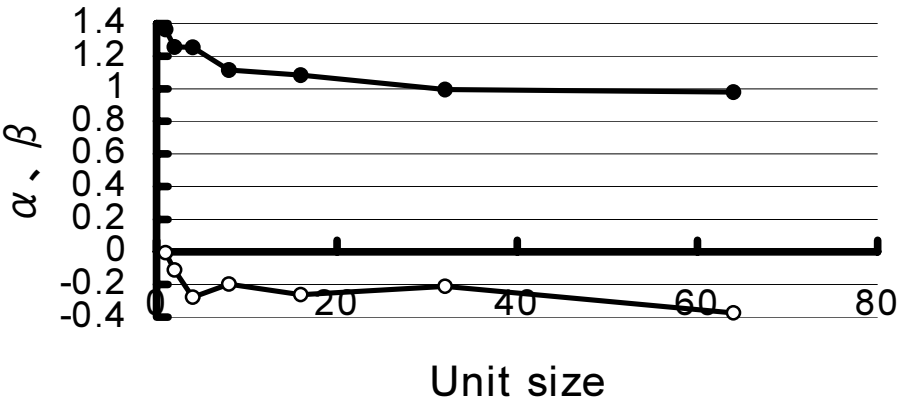


Fig. 3-18. The series m*-m relations of living *Juniperus procera* by changing quadrant size

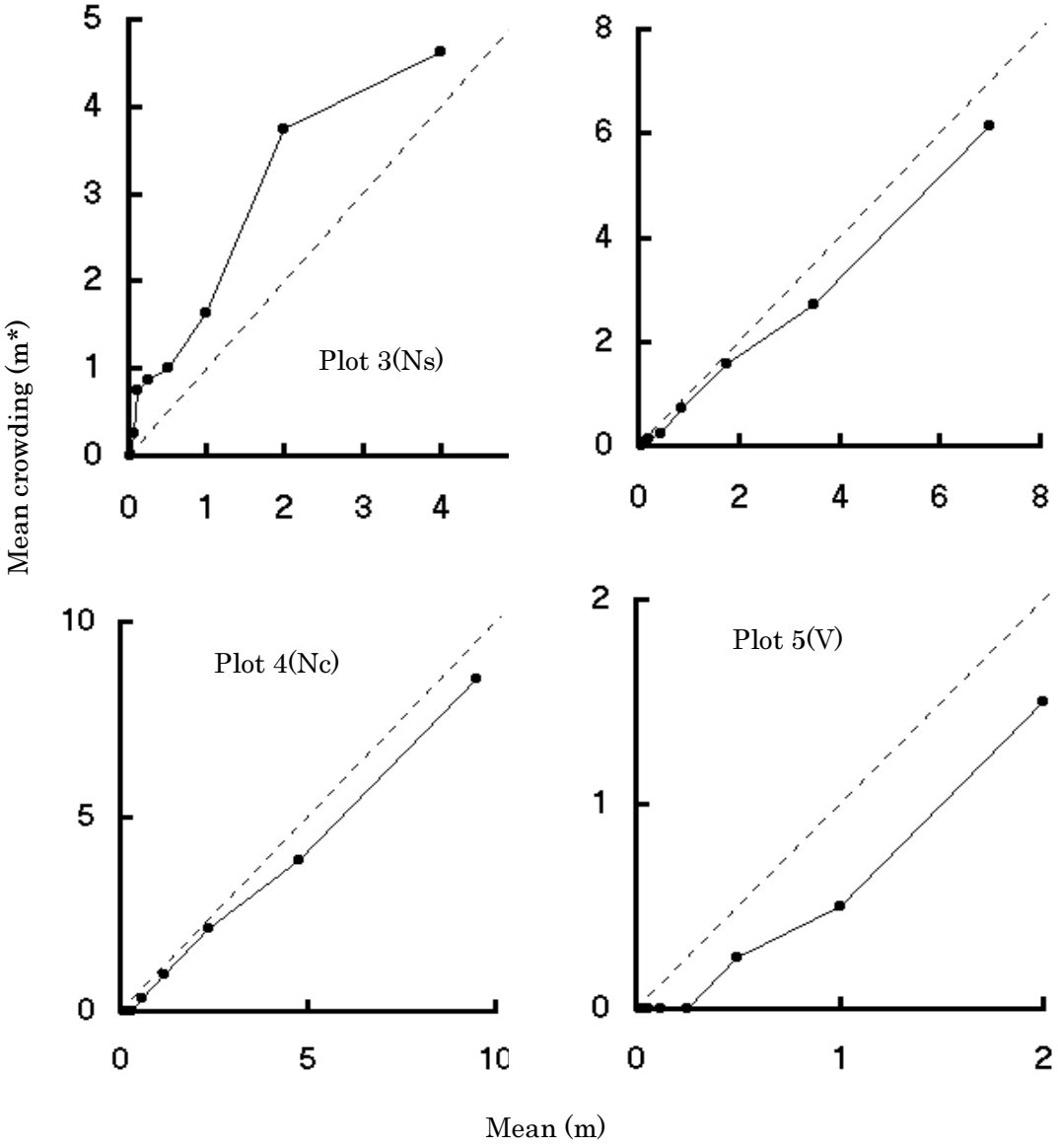


Fig. 3-19. The unit-size m*-m relations of stumps by changing quadrant size

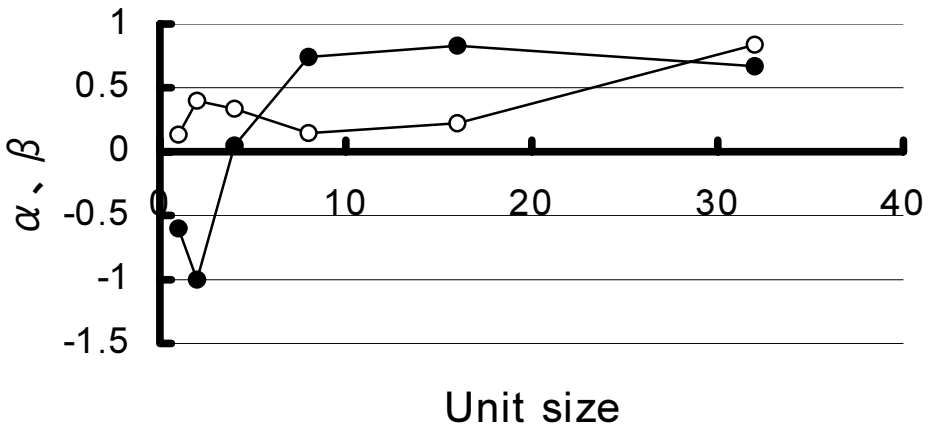


Fig. 3-20. The series m*-m relations of stumps by changing quadrant size

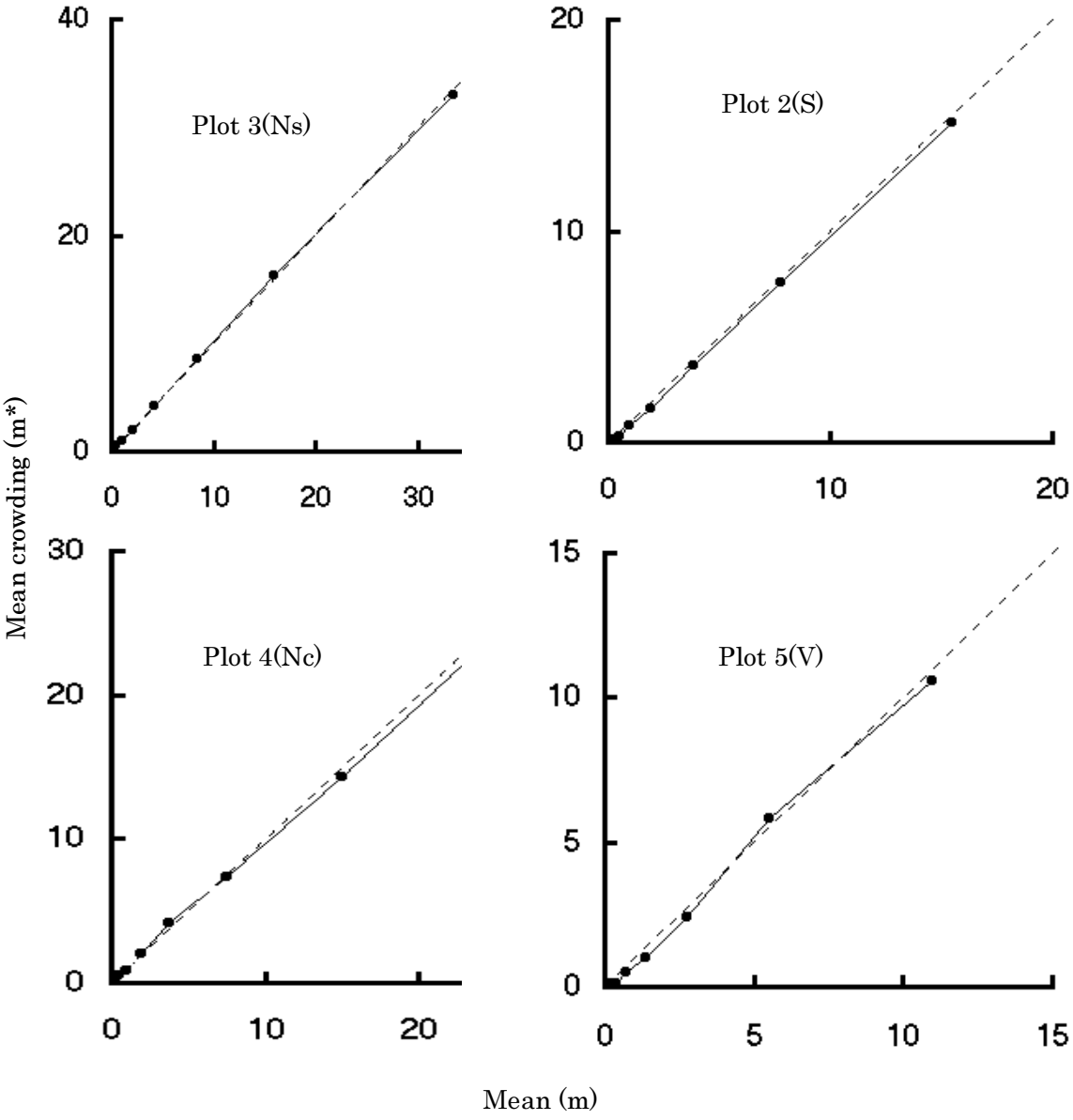


Fig. 3-21. The unit-size m*-m relations of all of *Juniperus procera* trees by changing quadrant size

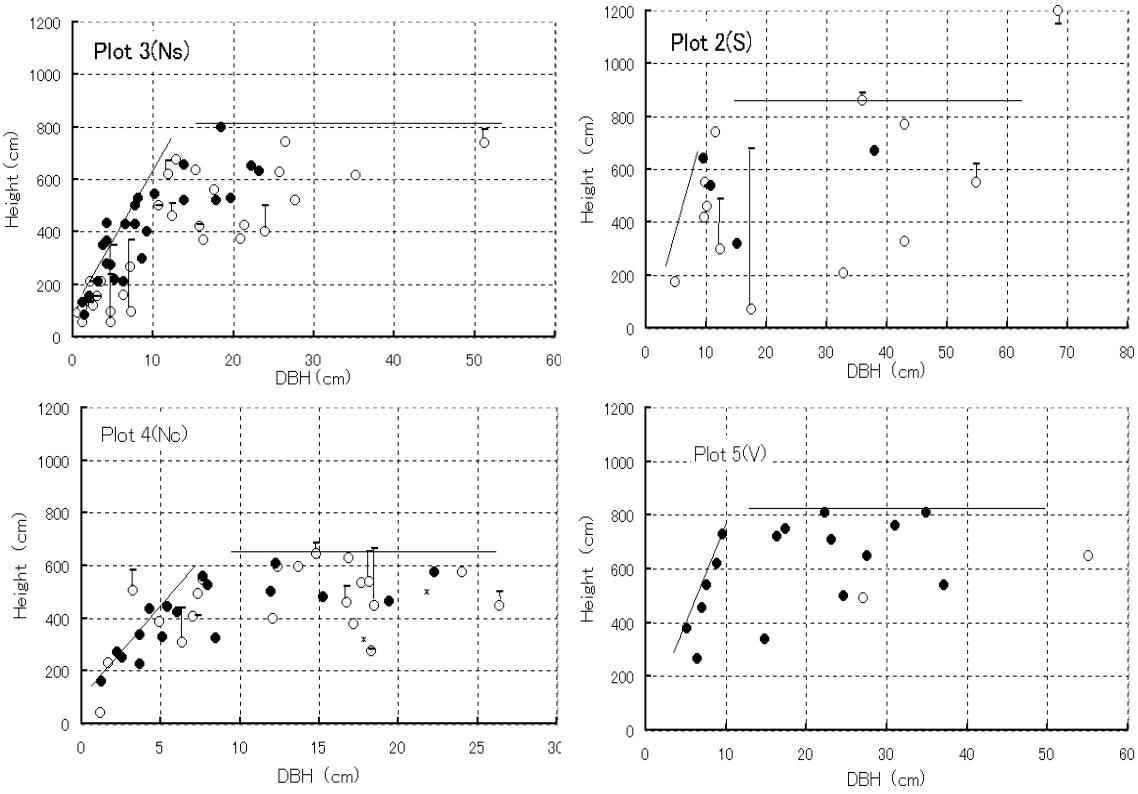


Fig. 3-22. Relationships between tree heights and DBH of *Juniperus procera* in each plot

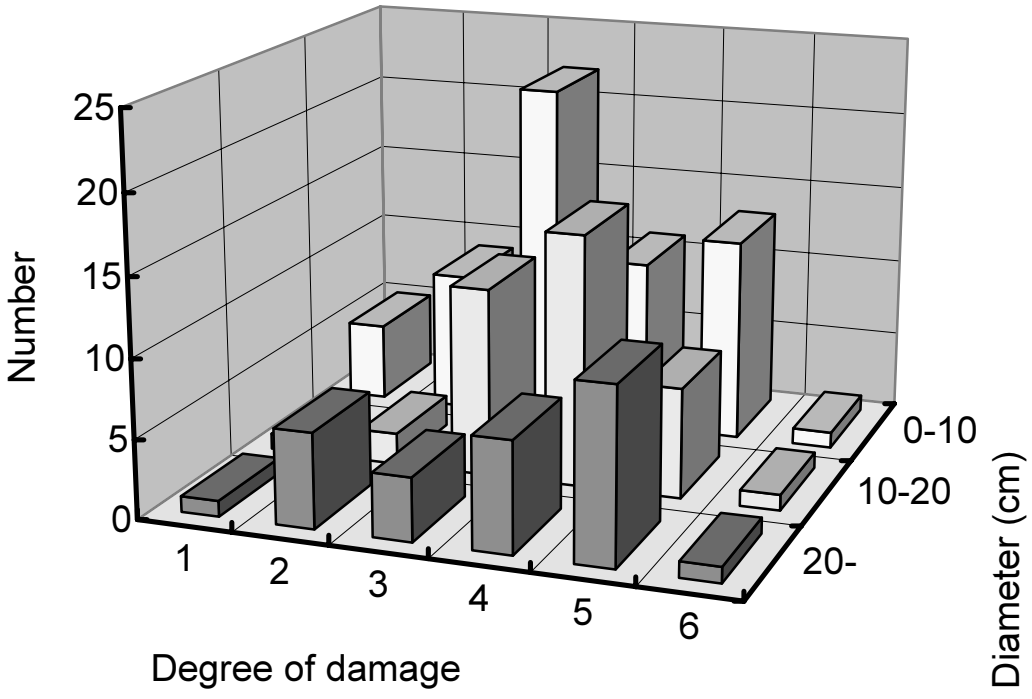


Fig. 3-23. Frequency distribution of tree numbers in damaged degree class of each diameter class

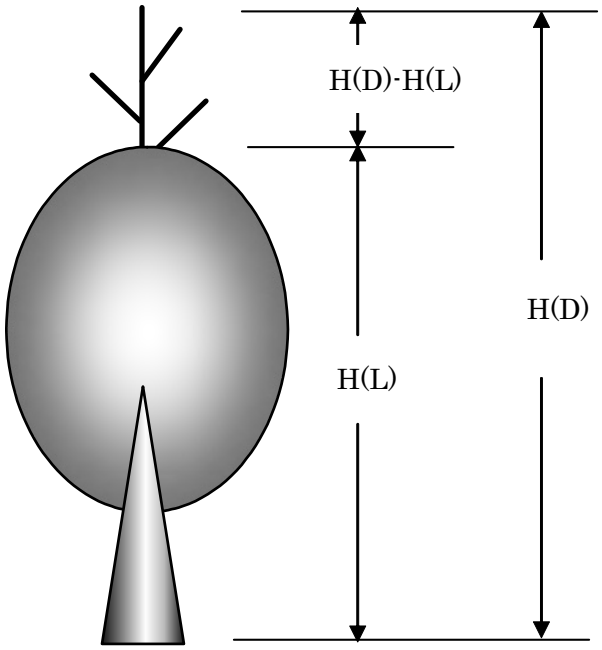


Fig. 3-24　Schematic explanation of damaged crown

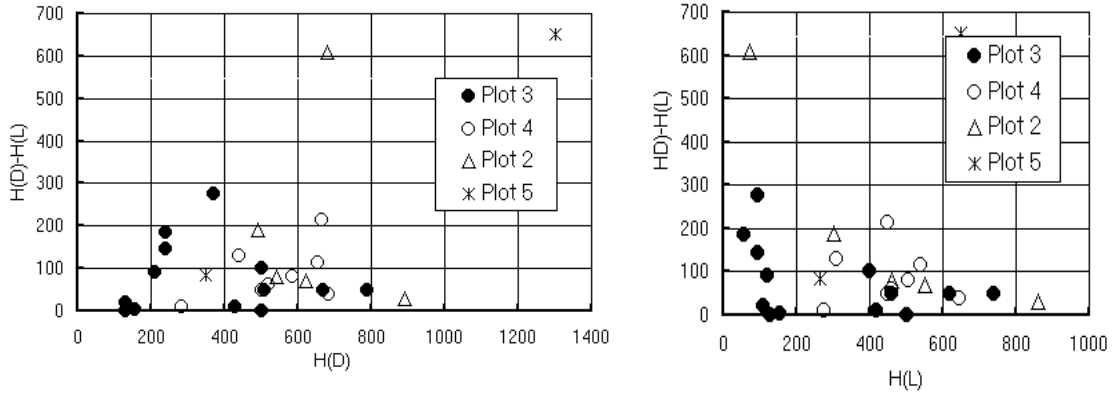


Fig. 3-25-1. Relationships between the heights of dead (H(D), upper) or living crowns (H(L), lower) and the stem lengths (H(D)－H(L)) of dead crowns in the four plots

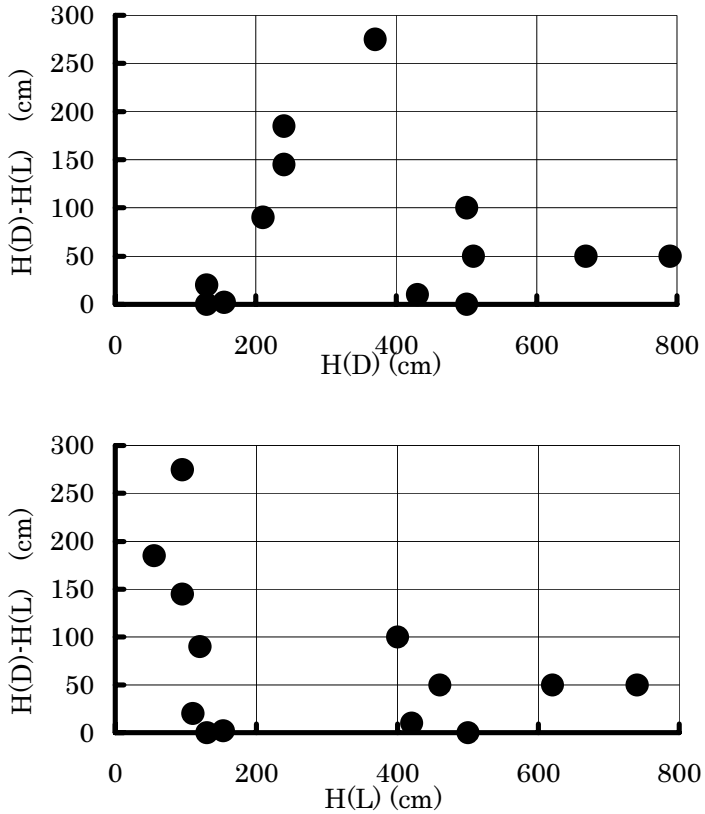
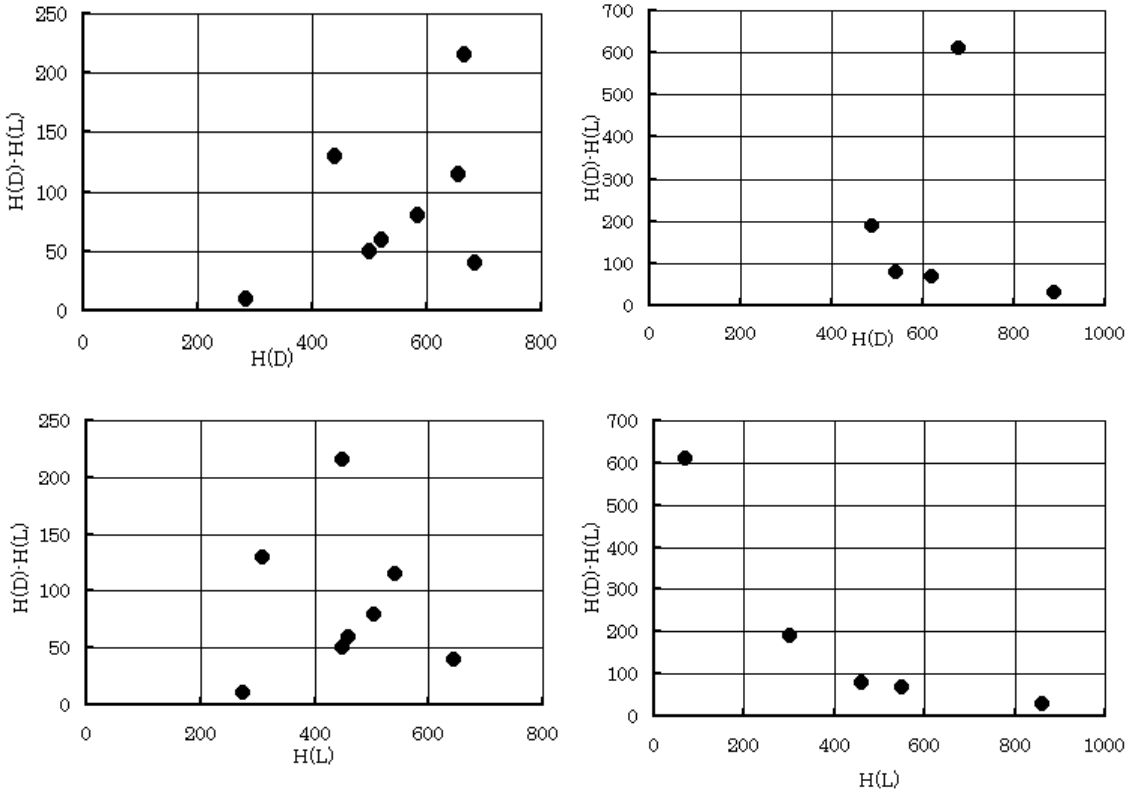


Fig. 3-25-2. Relationships between the heights of dead (H(D), upper) or living crowns (H(L), lower) and the stem lengths (H(D)－H(L)) of dead crowns in Plot 3(Ns)

(3) (4)



Figs. 4-25-3,4. Relationships between the heights of dead (H(D), upper) or living crowns (H(L), lower) and the stem lengths (H(D)－H(L)) of dead crowns in (3) Plot 4 (Nc) and (4) Plot 2 (S)

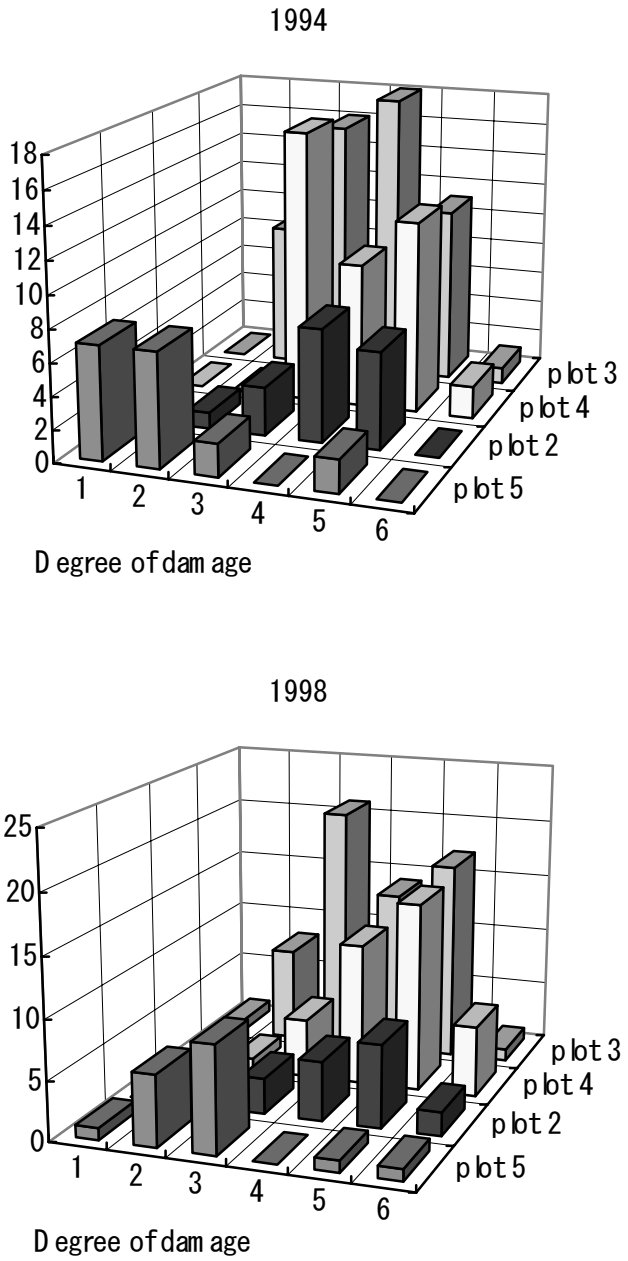


Fig. 3-26. Frequency distribution of tree numbers in damage degree class in 1994 and 1998

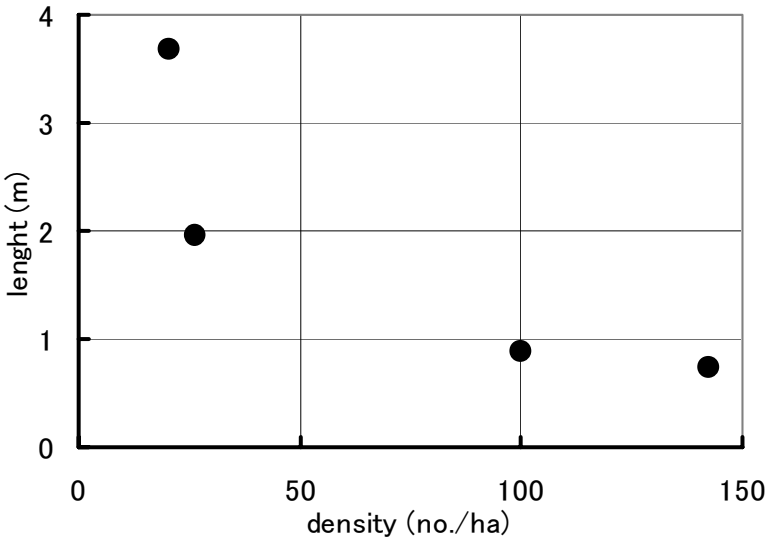


Fig. 3-27. Relationship between the tree density and the stem length of dead crowns

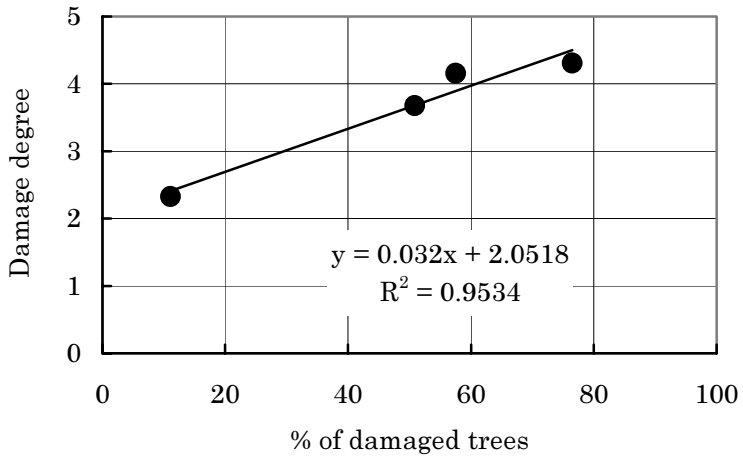


Fig. 3-28. Relationship between percentage of damaged tree numbers and damage degree

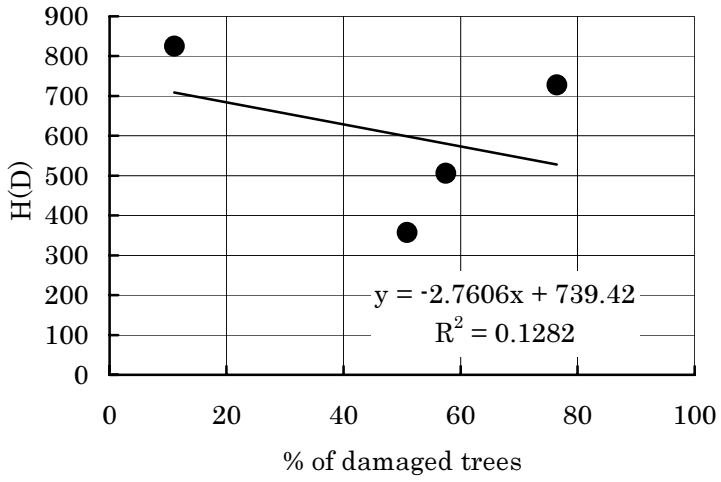


Fig. 3-29. Relationship between percentage of damaged tree numbers and height of dead crown (H(D))

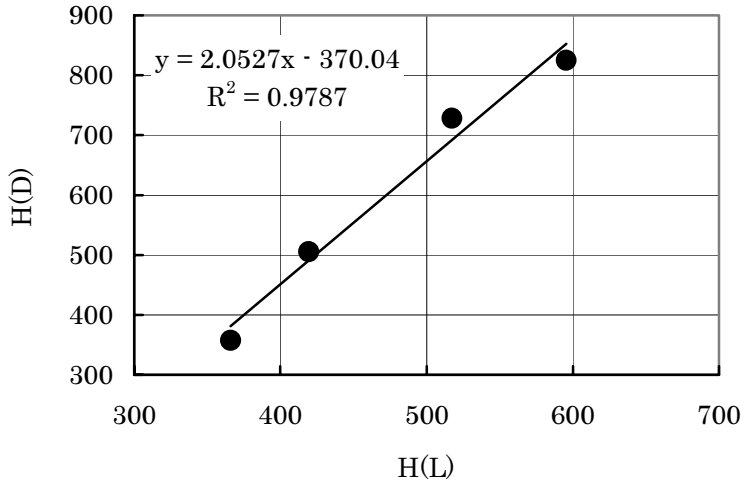


Fig. 3-30. Relationship of the heights between living crown (H(L)) and dead crown (H(D))

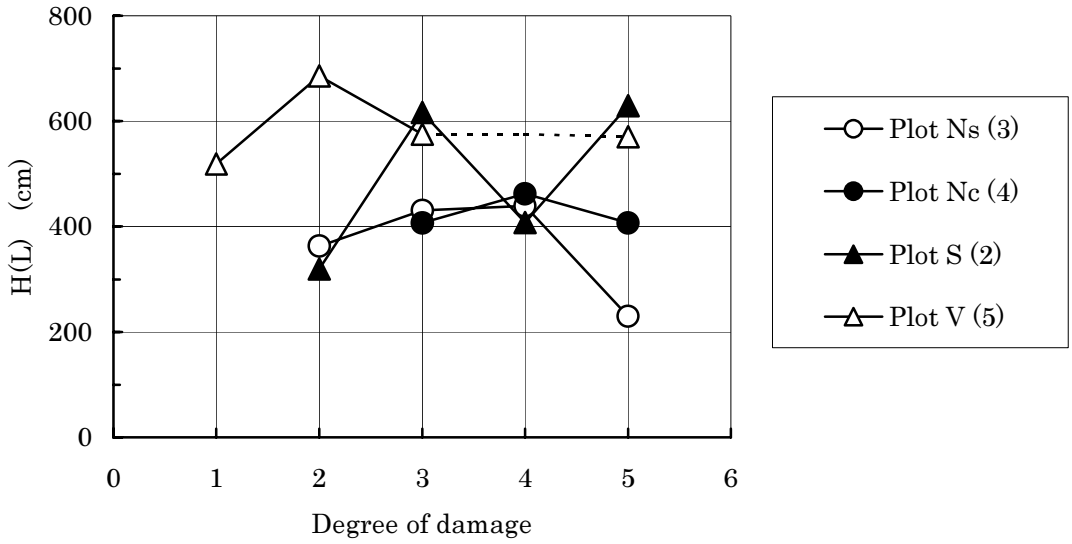


Fig. 3-31. Relationships between the damage degree and the mean height of living crown (H(L)) corresponding to each degree

4 Mycota of the Asir Mountains

Hiromitsu Hagiwara, Saleh A Al-Sohaibani, and Rabah Al-Harbi

Introduction

The Asir Mountains, which are over more than 2,000 m high, are located in southwest Saudi Arabia along the Red Sea. Precipitation in the mountains where there are woodlands is more than 200 mm in the spring and summer due to wet winds on the steep west side of the mountains. The Asir Mountains are, therefore, used as a summer resort area in Saudi Arabia. Recently, the biota of the region has been investigated by botanists, mycologists, and zoologists.

Though the woodlands contain East African (Somalia-Masai), Saharo-Sindian, and Afro-montane floristic elements, the flora of the Asir Mountains is poor when compared with subtropical floras at the same latitude in other parts of the world (e.g., the floras of Thailand in Asia and Mexico in Central America.)

The flora of the Asir Mountains, however, is still the richest flora in Saudi Arabia. It is, therefore, suspected that the fungus mycota of the Asir Mountains is comparatively rich. The fungi of Saudi Arabia are little known, partly because there have been few studies related to the fungi, and partly because papers on fungi written in Arabic are difficult to read by non-Arabic speaking people (Abdulaziz Al Mohanna, personal communication, 2001).

Information about the fungus mycota, particularly about plant pathogenic fungi and mycorrhizal fungi, is indispensable for keeping the woodlands in good condition. Our investigation of the fungi was performed at the Asir Mountains in September 2001.

Results and discussions

Five places in the Asir Mountains – Raydah, Tanumah, Billasmar, Tamniyah, and Jabal Thallan – were selected as sites for investigating the fungus mycota. A description of the sites and their characteristics are as follows:

1. Raydah Nature Reserve Area: The lower elevation limit of *Juniperus procera* is about 1,700 m. Below 1,700 m, *Teclea nobilis* (Rutaceae) and *Tarchonanthus camphoratus* (Compositae) are instead dominant (Ohba, 1999). An investigation was carried out along the road from Raydah Village (1,600 m) to the management office of the Raydah Nature Reserve (2,800 m) on 1, 2, 6, 11, 12, 13 and 15 September. The main sites of the investigation were as follows.

1) Roadside shrubs of *Centaurothamnus maximus* (Compositae) (2,600–2,700 m)

2) Near the Prayer Site (2,400 m)

3) Inside Plot 5 (2,390 m)

4) On the way to the 10 m Grass Pole Site (2,100 m)

5) Around the 5 m Pole Site (1,830 m)

2. Tanumah (2,200 m): juniper trees spreading horizontally on the north and south between steep hills. This woodland was artificially affected by the parking of cars and pasturage. The investigation was carried out on 8 September.
3. Billasmar (2,650 m): juniper woodland covering the mountaintop. This forest is almost purely *Juniperus procera*, but was mixed intermittently with *Erica arborea* (Ericaceae), a Mediterranean element. The investigation was carried out on 8 September.
4. Tamniyah (2,400 m): almost pure juniper woodland on flat ground surrounded by hills in all directions. Trees of *Acacia* origena and grasses grow along intermittent streams and around water coming from scattered hillocks. The investigation was carried out on 3 September.
5. Jabal Thallan (2,100 m): juniper woodland that had been nearly destroyed. On a steep slope near farmhouses, dead juniper trees were left with acacia trees, and the forest floor was densely covered by grasses and partially was becoming small fields. The investigation was carried out on 4 September.

Fifty-eight specimens of fungi, sensu stricto, and 62 myxomycetes were collected. The specimens of fungi included eight members of Uredinales, 11 of Aphyllophorales, four Hymenomycetales, 10 Gastromycetes, nine Pyrenomycetes, nine Discomycetes, and seven Imperfect Fungi.

Because it was the first investigation on the fungi at the Asir Mountains, the research team tried to collect common pathogenic fungi and mushrooms. The former includes rust fungi and mildew fungi, and the latter includes wood decaying fungi and mycorrhizal fungi, but only a few fungi were found. The poor results raised two questions. Was the investigation carried out during the most suitable time for the occurrence of fungi? Do the fungi occur so scattered in the Asir Mountains that a single, short-term investigation is hardly enough to discover all of them?

To solve these problems, it is necessary to make regular collections through the year, and to increase the number of investigators.

Sterilized dry specimens were sent to fungi specialists. The specimens identified included five species of Uredinales, five of Corticiaceae, 10 Gasteromycetes, and 20 Myxomycetes.

The species are enumerated alphabetically within each group. All the specimens examined for this report are preserved in the herbarium of the Department of Botany at the National Science Museum, Tokyo (TNS) in Japan, and in the herbarium of the National Commission for Wildlife Conservation and Development (NCWCD) in Riyadh, Saudi Arabia.

Uredinales (identified by Yoshitaka Ono)

Melampsora euphorbiae (Schub.) Cast. (II)

SA-F-43: on *Euphorbia shimperiana*, 2,651 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-F-54: on *Euphorbia helicoscopia*, 2,620 m, Al Qarn, Abha, 14 September 2001, leg. H. Hagiwara

SA-F-57: on *Euphorbia helicoscopia*, 2,450 m, Raydah, 15 September 2001, leg. H. Hagiwara

Puccinia acetosae Koernicke (II)

SA-F-53: on *Rumex dentatus*, 2,620 m, Al Qarn, Abha, 14 September 2001, leg. H. Hagiwara

Uromyces cligni Pat. and Har. (II and III)

SA-F-41: on *Andropogon* sp., 2,638 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-F-42: on *Andropogon* sp., 2,590 m, Raydah, 10 September 2001, leg. H. Hagiwara

Uromyces inaequialtus Lasch. (II)

SA-F-26: on *Silene* sp., 2,760 m, Raydah, 1 September 2001, leg. H. Hagiwara

Anamorphic Uredinales

Uredo sp.

SA-F-58: on *Pluchea dioscoridis*, 2,450 m, Raydah, 15 Sept 2001, leg. H. Hagiwara

Only a single uredospore was detected. Its morphological characteristics closely resemble those of many rust fungi on Compositae. Therefore, it is difficult to distinguish it from others on the basis of the uredospore.

Puccinia ocellifera is parasitic on *Pluchea*. Its uredospore has a remarkably thick and transparent part on the germination pore. However, a uredospore of SA-F-58 has not such a thick part, and also it is different in its shape from a typical one. Besides *P. ocellifera*, three species of *Aecidium* are known as parasites of *Pluchea*, but no species of *Uredo* are known from Saudi Arabia.

Corticiaceae (identified by Nitaro Maekawa)

Aleurodiscus sp.

SA-F-32: 2,125 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

This species is probably new to science.

Brevicellicium olivascens (Bres.) Larsson and Hjortstam

SA-F-33: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

Corticium lombardiae Larsen and Gilbertson

SA-F-21: 2,420 m, Raydah, 2 September 2001, leg. H. Hagiwara

Dendrocorticium roseocarneum (Schwein.) Larsen and Gilbertson

SA-F-49: 2,500-2760 m, Raydah, Sept. 12, 2001, leg. H. Hagiwara

Hyphodontia sambuci (Pers.) *J.* Eriksson

SA-F-40: 2,535 m, Raydah, 10 September 2001, leg. H. Hagiwara

Gastromycetidae (identified by Shoichi Yoshimi)

Bovista minor Morgan

SA-F-46: 2,050 m, Raydah, 11 September 2001, leg. Rabah Al-Harbi

Cyathus olla (Batsch) Pers.

SA-F-47: 2,050 m, Raydah, 11 September 2001, leg. Rabah Al-Harbi

Cyathus striatus (Huds.) Pers.

SA-F-5: 1,830 m, Raydah, 1 September 2001, leg. H. Hagiwara

Geastrum lageniforme (Vitt.) Imai

SA-F-34: 2,130 m, Raydah, 6 September 2001, leg. H. Hagiwara

Geastrum mirabile (Mont.) Fisch.

SA-F-3: 1,830 m, Raydah, 1 September 2001, leg. H. Hagiwara

Lycoperdon pusillum (Pers.) Schwn.

SA-F-8: 2,760 m, Raydah, 1 September 2001, leg. Rabah Al-Harbi

Lycoperdon sp.

SA-F-24: 2,550 m, Raydah, 2 September 2001, leg. Rabah Al-Harbi

It is difficult to distinguish this species from morphologically similar species using dry specimens.

Phallus sp.

SA-F-17: 2,395 m, Raydah, 2 September 2001, leg. Rabah Al-Harbi

It was impossible to identify this fungus because it was immature.

Tulostoma verrucosum

SA-F-30: 2125 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

Vascellum pratense (Pers.) Kreisel

SA-F-22: 2,160 m, Raydah, 2 September 2001, leg. Rabah Al-Harbi

Myxomycetes (identified by Yukinori Yamamoto)

Arcyria insignis Kalchbr. and Cooke

SA-M-61: 2,450 m, Raydah, 13 September 2001, leg. H. Hagiwara

Badhamia gracilis (T. Macbr.) T. Macbr.

SA-M-62: 1,940 m, Raydah, 15 September 2001, leg. H. Hagiwara

Badhamia populina A. and G. Lister

SA-M-42: 2,538 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-M-43: 2,537 m, Raydah, 10 September 2001, leg. H. Hagiwara (with *Physarum bitectum*)

SA-M-50: 2,490 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-M-58: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

Ceratiomyxa fruticulosa (Mueller) T. Macbr.

SA-M-8: 2,395 m, Raydah, 2 September 2001, leg. H. Hagiwara

Comatricha pulchella (C. Bad.) Rostaf.

SA-M-15: 2,125 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-52: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

Craterium leucocephalum (Pers.) Ditmar var. *cylindricum* (Massee) G. Lister

SA-M-12: 2,550 m, Raydah, 2 September 2001, leg. H. Hagiwara

SA-M-54: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

Craterium leucocephalum (Pers.) Ditmar var. *scyphoides* G. Lister

SA-M-17: 2,125 m, Raydah, 6 September 2001, H. leg. Hagiwara (with *Didymium squamulosum*)

SA-M-20: 2,125 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

SA-M-21: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

SA-M-25: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

Diderma hemisphaericum (Bull.) Hornem.

SA-M-22: 2,130 m, Raydah, 6 September 2001, leg. H. Takayama

SA-M-31: 2,625 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-35: 2,090 m, Jabal Tallan, 4 September 2001, leg. Rabah Al-Harbi

SA-M-53: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara (with *Physarum*

cinereum)

Didymium clavus (Alb. and Schw.) Rab.

SA-M-10: 2,395 m, Raydah, 2 September 2001, leg. H. Hagiwara

SA-M-23: 2,130 m, Raydah, 6 September 2001, leg. H. Hagiwara (with *Didymium* cf. *marineri*)

SA-M-47: 2,509 m, Raydah, 10 September 2001, leg. Rabah Al-Harbi (with *Didymium squamulosum*)

SA-M-55: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

Didymium iridis (Ditmar) Fr.

SA-M-9: 2,395 m, Raydah, 2 September 2001, leg. H. Hagiwara (with *Didymium squamulosum*)

SA-M-14: 2,650 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-30: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi (with *Craterium leucocephalum* var. *scyphoides*)

SA-M-51: 2,450 m, Raydah, 11 September 2001, leg. H. Hagiwara

SA-M-59: 2,450 m, Raydah, 13 September 2001, leg. H. Hagiwara

Didymium cf. *marineri* Moreno, Heykoop and Illana

SA-M-16: 2,125 m, Raydah, 6 September 2001, leg. H. Hagiwara

Didymium nigripes (Link) Fr.

SA-M-19: 2,125 m, Raydah, 6 Sepember 2001, leg. Rabah Al-Harbi

SA-M-49: 2,255 m, Raydah, 10 September 2001, leg. Rabah Al-Harbi (with *Didymium squamulosum*, *Physarum cinereum*)

Didymium squamulosum (Alb. and Schw.) Fr.

SA-M-5: 2,450 m, Raydah, 1September 2001, leg. H. Hagiwara

SA-M-6: 901-6 m, Raydah, 1 September 2001, leg. H. Hagiwara (with *Didymium nigripes*)

SA-M-18: 2,125 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-24: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

SA-M-28: 2,130 m, Raydah, 6 September 2001, leg. H. Takayama

SA-M-32: 2,125 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-46: 2,511 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-M-48: 2,509 m, Raydah, 10 September 2001, leg. Rabah Al-Harbi

Physarum bitectum G. Lister

SA-M-13: 2,560 m, Raydah, 2 September 2001, leg. H. Hagiwara

SA-M-44: 2,532 m, Raydah, 10 September 2001, leg. H. Hagiwara

SA-M-57: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

SA-M-60: 2,450 m, Raydah, 13 September 2001, leg. H. Hagiwara

Physarum cinereum (Batsch) Pers.

SA-M-1: 1,830 m, Raydah, 1 September 2001, leg. H. Hagiwara

SA-M-2: 2,000 m, Raydah, 1 September 2001, leg. H. Hagiwara

SA-M-3: 2,050 m, Raydah, 1 September 2001, leg. H. Hagiwara

SA-M-7: 2,160 m, Raydah, 2 September 2001, leg. H. Hagiwara

SA-M-27: 2,130 m, Raydah, 6 September 2001, leg. H. Hagiwara

SA-M-37: 2,090 m, Jabal Tallan, 4 September 2001, leg. Rabah Al-Harbi

SA-M-38: 2,090 m, Jabal Tallan, 4 September2001, leg. Rabah Al-Harbi

SA-M-39: 2,090 m, Jabal Tallan, 4 September 2001, leg. Rabah Al-Harbi

Physarum leucophaerum Fr.

SA-M-4: 2,050 m, Raydah, 1 September 2001, leg. H. Hagiwara

SA-M-11: 2,420 m, Raydah, 2 September 2001, leg. H. Hagiwara

SA-M-34: 2,090 m, Jabal Tallan, 4 September 2001, leg. Rabah Al-Harbi

SA-M-36: 2,090 m, Jabal Tallan, 4 September, 2001, leg. H. Takayama

Physarum leucopus Link

SA-M-26: 2,130 m, Raydah, 6 September 2001, leg. Rabah Al-Harbi

SA-M-29: 2,130 m, Raydah, 6 September 2001, leg. H. Hagiwara

Physarum cf. *luteolum* Peck

SA-M-33: Raydah, 1 September 2001, leg. H. Hagiwara

Physarum pusillum (Berk. and Curt.) G. Lister

SA-M-56: 2,500-2,760 m, Raydah, 12 September 2001, leg. H. Hagiwara

Willko mmlangea reticulata (Alb. and Schw.) O. Kuntze

SA-M-41: 2,538 m, Raydah, 10 September 2001, leg. Rabah Al-Harbi

Acknowledgement

We wish to thank Dr. Nitaro Maekawa, Dr. Yoshitaka Ono, Mr. Yukinori Yamamoto, and Mr. Shoichi Yoshimi for identifying the fungi.

5 Dieback phenomenon: a phytopathological study

Hiromitsu Hagiwara, Saleh A Al-Sohaibani, and Rabah Al-Harbi

Introduction

The phenomenon of dieback and die-off of *Juniperus procera* occurs throughout the Asir Mountains in southwest Saudi Arabia.

Symptoms of dieback and die-off appear to be caused by disease, but it is suspected that the phenomenon is not caused by plant pathogenic fungi, partly because the phenomenon is seen sporadically except in some places, and partly because dieback symptoms are not developed remarkable in periodical observation (Yamamoto, personal communication, 2001). It is hypothesized that the phenomenon began when the use of dead twigs and trees as fuel was replaced by the use of fossil fuels, such as petrol, and also because of global climatic change (Ohba, 1999). The phenomenon has therefore not been studied as a result of fungal disease.

Three species, *Seiridium unicorne*, *S. juniperi*, and *Phomopsis juniperovora*, are known as pathogenic fungi that cause dieback and die-off in *Juniperus* (Sutton, 1980; Sinclair et al., 1987; Bruck et al., 1990; Kobayashi, 1990). Additionally, *S. cardinale* is known to aggressively infect *Cupressus*, a genus closely related to *Juniperus* (Sinclair et al., 1987).

1. Isolation of the pathogenic fungi from symptomatic tissues

Generally several steps are required to determine a plant pathogenic fungus. The first is to isolate the pathogen from symptomatic tissues of the diseased plant, and then culture and identify it. Next, a healthy host plant is inoculated with the pathogen to see if it causes the same disease. It is then isolated again from symptomatic tissues of the newly diseased plant and identified. An investigation was carried out in the Asir Mountains in September, 2001 to determine if the pathogenic fungi mentioned above are on the dead twigs of *J. procera*. This was the main query of our preliminary study.

Dead and living twigs were cut from the trees of *Juniperus* showing dieback and then dried. The dried samples were packed into polyethylene bags and taken to Japan, where they were examined for fungi growing on the outside of the twigs and from which fungi was isolated from the symptomatic tissues. The examination was carried out at the Forestry and Forest Products Research Institute in Tsukuba, Japan.

Material examined

1. Six dead twigs from juniper trees in Raydah Nature Reserve Area on 1 and 11 September.
2. Five dead twigs from juniper trees at Billasmer on 8 September.

Spores of *Phomopsis* were detected on the dead twigs of *Juniperus procera*. They were clearly different, however, from the spores of *Phomopsis juniperovora*. Spores of other pathogenic fungi were not found.

In examining the isolates, no species of *Seiridium* were found. One species of *Phomopsis* was obtained, but it was the same species found on the dead twigs and is not a pathogen of *Juniperus*. *Phomopsis* is parasitic on various trees and causes dieback, but it generally occurs when the trees become weak from other causes. Besides *Phomopsis*, several species of *Colletotrichum*, *Cytospora*, *Cytosporella*, *Fusarium*, *Harknessia*, *Microsphaeropsis* and *Phoma* were recognized. They are parasitic on twigs of various trees, but it is believed that they are secondary infectors and not strongly aggressive. These facts suggest the following two conclusions.

The dieback of *Juniperus procera* in the Asir Mountains is not caused by any known pathogenic fungi of *Juniperus*.

Even if other pathogenic fungi are involved, they infect weakened trees of *Juniperus procera*.

2. The effect of fungi on dieback and die-off

We studied the effects of fungi on the dieback and die-off of junipers in the Raydah Nature Reserve and in the Tamniyah Ministry of Water and Agricultural Nature Reserve.

Ten samples of the roots of juniper and 10 samples of the soil surrounding the roots were collected in plastic sacs from 10 to 13 September 2001.

1. One from healthy trees in the Raydah Nature Reserve Area
2. Four from trees with dieback in the Raydah Nature Reserve Area
3. Two from trees with die-off in the Raydah Nature Reserve Area
4. One from healthy trees in the Tamniyah Area
5. Two from trees with dieback in the Tamniyah Area

Fresh segments of roots were fixed and stained for examination of the mycorrhizae in our laboratory at King Saud University.

Pot cultures were used to inoculate and grow Sudan grass, *Sorghum sudanese* (Piper) Stapf,

with different soil samples. Ten grams of each soil sample were placed in a hole 5 cm deep as inoculum. In each hole, one seed of Sudan grass was planted.

Plant height, number of leaves and number of branches were recorded for each treatment at weekly intervals for 15 weeks. The plants were harvested after 15 weeks. Half of the plants was used to determine the fresh and dry weight of the shoot and root systems; the other half of the plants was used to determine the degree of root mycorrhizal colonization.

Microscopic examination of juniper fresh root segments showed that healthy junipers were heavily colonized (more than 60%) by some vesicular-arbuscicular mycorrhizal (VAM) fungi, while the roots of junipers with dieback were less colonized (fewer than 40%). Junipers with die-off had very few colonized roots (fewer than 10%).

The results from the pot cultures indicate that the roots of Sudan grass inoculated with soil surrounding the roots of healthy junipers had a higher percentage of mycorrhizal colonization than those of junipers with dieback or die-off. No mycorrhizal colonization was found in uninoculated plants of Sudan grass.

Generally, VAM plants are heavily dependent on mycorrhizae for growth and nutrient uptake. A reduction in mycorrhizal colonization is associated with a decrease in root exudation of amino acids and reducing sugars, decreased root development, and decreased root branching as a result of a lower rate of photosynthesis in the shoot system of unhealthy plants. Results of this preliminary, short-term study imply that the general VAM effect shows up in junipers.

It is well known that the growth of junipers is influenced by several environmental factors. We should therefore consider the limiting factors of interactions by other organisms on the growth rate of junipers in future studies.

Acknowledgement

We are deeply grateful to Dr. Shigeru Kaneko for inspecting the pathogenic fungi on twigs of *Juniperus procera* with dieback, as well as for reading the manuscript and for his valuable suggestions.

References

Bruck, R.I., Solel, Z., and Ben-Ze°Ev, I.S. 1990. New diseases of trees in Israel. Phytopathology, 80: 977.

Kobayashi, T. (ed.). 1990. Damage and epidemiology of *Seiridium* canker of Japanese cypress and its control measures (in Japanese), pp. 70. Tokyo: Forest Development Technological Institute.

Ohba, H. 1999. The forest in desert (in Japanese). Kagaku, 69: 811-818.

Sinclair, W.A., Lyon, H.H., and Johnson, W.T. 1987. Diseases of trees and shrubs, pp. 512. Ithaca: Cornell Univ. Press.

Sutton, B.C. 1980. The Coelomycetes, pp. 696. CMI, Kew.

6 Flora of the Asir Mountains

Hideaki Ohba, Tarik Abbasi, Taku Miyazaki, and Abdullah Wetaid

Introduction

To obtain data on living organisms, accurate identification is the basis of scientific study. A flora is a taxonomic or systematic treatment of the plants of a given region. It provides us with a comprehensive and systematic account of the biodiversity of the area being studied and arranges the information accumulated over time from the field, herbarium and literature studies in an organized scientific manner. The simplest way to present an account of the flora is in a checklist, which is a list of the names of the species and infraspecific taxa occurring within a given region.

The Flora of Saudi Arabia has been studied by various authors since Forsskål (1775). Recently Migahid (1973), Collenette (1965, 1999), and Chaudhary (1999, 2000) published their works on the Saudi Arabian flora. Since the 19th century, the diversity of species in the Asir Mountains has been investigated by many researchers, but no reliable regional flora, not even a checklist, has been published.

To prepare a flora we must survey all the vegetation types and collect representative specimens. The specimens are dried and stored in a herbarium after mounting on sheets of archival quality paper, along with data on the locality, date of collecting, collector's name and field number, remarks on the habitat, habit and color of the flowers and fruits, and any other information that will not be obvious on the dried specimens.

During this project we surveyed the vascular plants (flowering plants and pteridophytes) and fungi, and prepared at least two sets of specimens, of all that we encountered. The first complete set is preserved in the museum of the NCWCD in Riyadh, while the second set of flowering plants and pteridophytes is kept in the Herbarium of the University Museum at the University of Tokyo (TI). The fungi are in the National Science Museum, Tokyo, (TNS) at Tsukuba. Some further duplicates of the flowering plants were sent to the herbaria at Harvard University (A), the Missouri Botanical Garden (MO), the Royal Botanic Garden Edinburgh (E), and other locations.

1 Flora of the Asir Mountains

Conserving global and regional biodiversity is one of the major goals of our society in the 21st century. For this we need to know the present situation of biodiversity. Vascular plants are the main

elements of the vegetation and landscape. The quality and variety of the vegetation and landscape depend on the diversity of plants.

The Raydah Nature Reserve and the adjacent areas in the Asir Mountains are remarkable in that their great variety of vegetation is principally classified into montane woodlands of *Juniperus procera*, drought-deciduous thorn woodlands with many species of *Acacia*, shrublands and others. The diversity of species in the area is the highest in Saudi Arabia.

1.1 Floristic features

Of the 460 species we collected in the Raydah area, we were able to identify 385, with 75 species being unidentifiable. Ten of the species are cultivated or naturalized. Of the total species, 134 are distributed widely in paleotropical regions in the northern hemisphere and in other regions. A checklist of vascular plants is given as an Appendix.

The flora of the Raydah Nature Reserve Area and the adjacent areas in the Asir Mountains (including some isolated areas where *Juniperus procera* and juniper woodlands occur) is notable in having the highest species diversity on the Arabian Peninsula.

Miller and Cope (1996) estimated that the number of the native species in Saudi Arabia is 1,800. Based on that figure, about 25% (450 species) of all the species of Saudi Arabian plants are found in Raydah and adjacent areas, indicating a relatively high diversity of vascular plant species in the areas surveyed.

1.2 Endemism

Miller and Cope regarded 35 species (2%) to be endemic to Saudi Arabia. The exact number of endemic species in Raydah and adjacent areas is uncertain, but the following are considered to be endemic to the Arabian Peninsula, including Yemen, the United Arab Emirates and other countries: *Phragmanthera austroarabica* (Loranthaceae), *Maerua triphylla* var. *calophylla* (Capparaceae), *Reseda sphenocleoides* (Resedaceae), *Kalanchoe deficiens* (Crassulaceae), *Rubus asirensis* (Rosaceae), *Polygala schwartziana* (Polygalaceae), *Grewia velutina* (Tiliaceae), *Swertia polynectaria* (Gentianaceae), *Galium aparinoides* and *G. kahelianum*, *Pavetta longiflora* and *P. pammalaka* (Rubiaceae), *Micromeria imbricata*, *Nepeta deflersiana*, *Plectranthus asirensis* (Lamiaceae), *Anthemis yemenensis*, *Centaurothamnus maximus*(Asteraceae), *Aloe castellorum*, *A. fleurentiniorum*, *A. sabaea*, and *A. shadensis* (Asphodelaceae). The number of endemic species will increase through further studies, especially in the genera *Plectranthus* (Lamiaceae), *Anthemis*,

Echinops (Asteraceae), *Galium* (Rubiaceae), and *Aloe* (Asphodelaceae).

Centaurothamnus maximus.

The most remarkable species is undoubtedly *Centaurothamnus maximus*, which was described by Pehr Forsskål as *Centaurea maxima* in his monumental work, *Flora Aegyptiaco-Arabica* in 1775. Forsskål collected it in Barad, Yemen (Barah in montibus Yemen) in 1763. This was the sole collection of this species. Vahl (1790) named the same collection *Centaurea verbascifolia* in his *Symbolae Botanicae*, volume 1. Vahl's name is superfluous, since it was based on the same type *Centaurea maxima*, and illegitimate. In 1982, Wagenitz and Dittrich established the new genus *Centaurothamnus*, based on *Centaurea maxima* Forssk. in *Candollea* volume 37.

Centaurothamnus is monotypic, represented only by the single species, *Centaurothamnus maximus*. Collenette (1999) gave the locality as "Between Jabal Ibrahim and Al Bahah, off the Taif–Abha road, on a cliff on the lip of the escarpment 7,000 ft." Chaudhary (2000) reported further localities from specimens in the National Herbarium of Saudi Arabia, the National Agriculture and Water Research Center of the Ministry of Agriculture and Water. They are Habla (Chaudhary s.n.), Raidah (Chaudhary s.n.), and Abha (Abedin and Mossa, 13166, 13317). Wood (1997) mentioned a locality in Yemen as "on cliff between 1,700 and 3,200 m; widespread and frequent on the escarpment; rare on the high plateau." Hosni and Hegazy (1996), in their paper "Contribution to the flora of Saudi Arabia," did not list *Centaurothamnus*.

In our research, *Centaurothamnus maxima* was observed and collected at several sites on steep collapsed roadside banks in the juniper woodlands of the Raydah Nature Reserve at 2,800 m. The size of the populations vary from changing to year, and are adventitious. To conserve this species, it is necessary to maintain the juniper woodlands as well as temporal unstable exposed situations, which appear to be necessary for the establishment of *Centaurothamnus*.

2 Phytogeography

The distribution of all taxa was investigated and classified according to the following categories.

SM: Somalia-Masai type. This distribution includes the southwest part of the Arabian Peninsula, Ethiopia, Somalia, and Kenya. It corresponds to the floristic region called the Eritreo-Arabian Province by Zohary (1973).

SS: Saharo-Sindian type. This corresponds to the Saharo-Arabian region of Zohary.

TA: Tropical African type. This includes species ranging in location from the Arabian Peninsula to tropical Africa.

M: Mediterranean type. These species range in location from the Mediterranean region to the Arabian Peninsula.

IT: Irano-Turanian type. Species in the Irano-Turanian region with extensions to the Arabian Peninsula.

A: Afro-montane type. These species occur at higher elevations from montane regions in the southwest Arabian Peninsula to East Africa (Ethiopia, Kenya, and other countries).

W: Widely distributed type. These species are widely distributed in paleotropical regions and sometimes also in temperate regions.

CN: Cultivated or naturalized.

White (1983) proposed a phytogeographical system for Africa based on his theory of the phytochorion as a regional center of endemism separated by transitional zones and regional mosaics. A phytochorion has more than 50% of its species confined to it and a total of more than 1000 endemic species. This system was extended to southwest Asia, including the Arabian Peninsula, by Léonard (1989) and White and Léonard (1991).

The *Juniperus procera*-dominated woodlands are the main vegetation community at higher elevations in the Asir Mountains. *Juniperus procera* is isolated from the main range of its distribution in East Africa (from Tanzania to Ethiopia), where it also occurs in montane areas. The Asir Mountains are the only locality for *Juniperus procera* in the Arabian Peninsula and mark the northern limit of its distribution. There are a considerable number of associated species in the woodlands that are disjunctly distributed in both Africa and on the Arabian Peninsula.

One of the phytochoria is the Afro-montane archipelago-like regional center of endemism. This phytochorion is characterized by the presence of a *Juniperus procera* semi-evergreen bushland and thickets with *Acacia origena*, *Buddleija polystachya*, *Catha edulis*, *Cussonia holstii*, *Dombeya torrida*, *Erica arborea*, *Hypericum revolutum*, *Nuxia congesta*, *Rosa abyssinica*, and *Teclea nobilis* (Miller and Cope, 1996). All except *Catha edulis* and *Cussonia holstii* have been found in our survey areas.

Species within the Afro-montane archipelago-like regional center of endemism are classified into nine types according to their distribution. The species of this type occur from the higher

montane regions in the southwest part of the Arabian Peninsula to East Africa (Ethiopia, Kenya, and some other countries). Only four species (*Oncocalyx glabratus*, *O. schimperi* and *Phragmanthera austroarabica* (Loranthaceae), and *Dianthus strictus* subsp. *sublaevis* (Caryophyllaceae), in addition to *Juniperus procera*, are classified as this type.

The widely distributed type W was the most common type in our survey areas. Species of this type are widely distributed in paleotropical regions and sometimes also in temperate regions. The second most common type is the Somalia-Masai type (SM), with 103 species (22.4%). This type ranges in location from the southwest part of the Arabian Peninsula to Ethiopia, Somalia, and Kenya, and corresponds to the Eritreo-Arabian Province of Zohary (1973). It was noted that the number of species (103) in the juniper woodlands and other vegetation at higher elevations belonging to the SM type is more than the total number of SS, TA, M, IT types combined (95 species), indicating that the flora in our survey areas has a strong affinity to the flora in the highlands of Ethiopia, Somalia, and Kenya. Some representatives of the SM type are *Commiphora spp*., *Dobera glabra*, species of Capparaceae, *Rosa abyssinica*, *Cadia purpurea*, *Indigofera amorphoides*, *Geranium arabicum*, *Clutia myricoides*, *Rhus retinorrhoea*, *Grewia spp.*, *Euclea schimperi*, *Acokanthera schimperi*, *Lavandula dentata* and *L. pubescens*, *Micromeria imbricata*, *Otostegua fruticosa* subsp. *schimperi*, *Solanum schimperianum*, *Euryops arabicus*, *Felicia abyssinica*, *Senecio hadiensis* and *S. schimperi*, and *Tarchonanthus camphoratus*. Comparisons of the floras in the Asir Mountains and the highlands of Ethiopia, Somalia, and Kenya will be necessary for further discussions on the floristic relationships.

3 Remarkable and endangered species

Rare and endangered species in the area have not been investigated for the purpose of conservation of biodiversity. It is necessary to conserve the habitat of many species, particularly those of the herbaceous plants that grow sporadically in and by woodlands and thickets, which are presumed to be vulnerable to any disturbances. Species considered to be endangered and rare are listed tentatively below.

Centaurothamnus maximus (Forssk.) Wagenitz & Dittrich

Although data on *Centaurothamnus maxima* are still limited, our observations in the mountains are enough to determine that this species should be placed in the threatened status or at least considered to be vulnerable or endangered according to the RDB category by IUCN (1994).

Oncocalyx glabratus (Engl.) M. G. Gilbert (Loranthaceae)

This parasitic species is rare and has been collected only twice in Saudi Arabia. We collected it at Al-Abard, Abha at 2,380 m.

Oncocalyx schimperi (Hochst. ex A. Rich.) M. G. Gilbert (Loranthaceae)

This was collected at Al-Abard (2,380 m) and at Raydah Village (1,500−1,730 m).

Phragmanthera austroarabica A. G. Mill. & J. Nyberg (Loranthaceae)

This parasitic species, endemic to Saudi Arabia and Yemen, was collected at Al-Sudah (2,700 m), Ghara (2,340 m), between Ghara and Abha (2,470 m), Ghara-Tamniyah (2,500 m), Tamniyah (2,360–2,550 m), and Tanumah (2,280 m). At present, it appears to be common in the higher elevations of the Asir Mountains

Dianthus strictus Banks. & Soland. subsp. *sublaevis* D. F. Chamb. (Caryophyllaceae)

This is a tiny herb that grows sparsely in exposed rock crevices at higher elevations.

Kalanchoe citrina Schweinf. (Crassulaceae)

This species, with a limited range, was found sporadically on exposed rocky habitats and is rare.

Kalanchoe deficiens (Forssk.) Asch. & Schweinf. (Crassulaceae)

Kalanchoe glaucescens Britten (Crassulaceae)

These are stonecrops found rarely in shaded, rocky places.

Umbilicus rupestris (Salisb.) Dandy (Crassulaceae)

This was found sporadically among stones in terrace fields.

Rosa abyssinica Lindl. (Rosaceae)

This wild rose was found sporadically on the margins of thickets and shrubs in our survey areas.

Rubus asirensis D. F. Chamb. (Rosaceae)

This is endemic to the Asir Mountains. Two specimens were collected from somewhat shaded places at the foot of cliffs between 2,280 and 2,500 m.

Gnidia somalensis (Franch.) Gilg (Thymelaeaceae)

Richards (1994) reported this from Al Souda, the Asir Mountains. We we did not, however, find it during our survey.

Primula verticillata Forssk. (Primulaceae)

Richards (1994) reported this from the Asir Mountains. We did not, however, find it during our survey. Instead, it was found along the lower sections of a stream. Richards mentioned that it grew exclusively on very wet, mostly shaded cliffs, often rooted in tufa. In the Asir region, the sandstone was evidently calcareous. It appears to be rare.

Swertia polynectaria (Forssk.) Gilg (Gentianaceae)

This species, collected at Sudah (2,950 m), appears to be rare. Its habitat needs protection from housing land development.

Adenium obesum (Forssk.) Roem. & Schult. (Apocynaceae)

This was rather common in a dry valley at lower elevations, but the vegetation was destroyed to create pasture land. Khamis Mushayt (2,160 m) was the highest locality in our survey.

Plectranthus asirensis J. R. I. Wood (Lamiaceae)

This is a narrow endemic and only known in the Asir Mountains. We collected it at two localities: Raydah Village (1,640 m) and Jabal Fayfa, Jizan (1,820 m).

Anthemis yemenensis Podlech (Asteraceae)

Kleinia odora (Forssk.) DC. (Asteraceae)

This is a succulent herb found in rock crevices and on stone walls. Because of its ornamental value it has been reduced in numbers through collecting.

All species of *Aloe* (Asphodelaceae)

Aloe is an important horticultural resource and any of the wild species are used as ornaments by local peoples or removed by collectors. Protection against collecting is necessary.

References

Batanouny, K. H. and N. A. Baeshin. 1978. Studies in the flora of Arabia 1. Taeckholmia 9: 67–81.

Blatter, E. 1919–36. Flora Arabica. Rec. Bot. Surv. India 8: 1–519.

Boulos, L. 1985.Contribution to the flora of the Mountains, Saudi Arabia. Arab Gulf *J.* Sci. Res. 3: 67–94.

----------. 1995. Notes on *Acacia* Mill. Studies in the Leguminosae of Arabia: 1. Kew Bull. 50: 327–337.

Brooks, W.H. and KK. S.D. Mandil. 1983. Vegetation dynamics in the woodlands of southwestern Saudi Arabia. *J.* Arid. Envir. 6: 357–362.

Brummitt, R.K. (ed.). 1992. Vacular plant families and genera. Royal Botanic Gardens, Kew.

Chaudhary, S.A. (ed.). 1983. *Acacia* and other genera of Minosoideae in Saudi Arabia. National Herbarium, National Agriculture and Water Research Center, Ministry of Agriculture and Water, Riyadh.

----------. 1989. Grasses of Saudi Arabia. National Herbarium, National Agriculture and Water Research Center, Ministry of Agriculture and Water, Riyadh.

----------. 1999 and 2000. Flora of the Kingdom of Saudi Arabia Illustrated. Vol. 1 (1999), Vol. 3 (2000). National Herbarium, National Agriculture and Water Research Center, Ministry of Agriculture and Water, Riyadh.

Collenette, S. 1985. An Illustrated Guide to the Flowers of Saudi Arabia. London: Scorpion Publishing.

----------. 1999. Wildflowers of Saudi Arabia. National Commission for Wildlife Conservation and Development (NCWCD), Riyadh.

Fischer, M. and D.A. Membery. 1998. Climate. In: Ghazanfar, S.A. and M. Fischer (eds.), Vegetation of the Arabian Peninsula, pp. 5–38.

Forsskåk, P. 1775. Flora Aegypotiaco-Arabica. Copenhagen.

Ghazanfar, S.A. and M. Fischer (eds.). 1998. Vegetation of the Arabian Peninsula. Dordrecht, Netherlands: Kluwer Publishers.

Green, P. S. and G. E. Wickens. 1989. The Olea europaea complex. In: Kit Tan (ed.), The Davis and Hedge Festschrift. Edinburgh: Edinburgh University Press, pp. 287–299.

Heller, D. and C.C. Heyn. 1986–94. Conspectus Florae Orinetalis. Fasc. 3–9. Jerusalem: Israel Academy of Sciences and Humanities.

Hosni, H.A. and A.K. Hegazy. 1996. Contribution to the flora of, Saudi Arabia. Candollea 51: 169–202.

König, P. 1986. Vegetation und Flora im südwestlichen Saudi-Arabien (Tihama). Diss. Bot., No. 101.

Léonard, J. 1988-89. Contribution à l'étude de la flore et la végétation des deserts d'Iran, fasc. 8 (Étude des aires de distribution. Les phytochories. Les chorotypes) and 9 (Considérations phytogéographiques sur les phytochories irano-touranienne, saharo-sindienne et de la somalie-pays Masai).

Mandaville, J. P. 1973. A Contribution to the Flora of Southwestern Arabia. Miami, Florida: Field Research Publ.

----------. 1984. Studies in the Flora of Arabia: XI, some historical and geographical aspects of a principal floristic frontier. Notes Roy. Bot. Gard. Edinburgh 42: 1–15.

Migahid, A.M. 1988-89. Flora of Saudi Arabia, ed. 3. Riyadh: King Saudi University.

Miller, A.G., Hedge, I.C. and R.A. King. 1982. Studies in the Flora of Arabia: I. A botanical bibliography of the Arabian Peninsula. Notes Roy. Bot. Gard. Edinburgh 40: 43–61.

--------- and T.A. Cope. 1996. Flora of the Arabian Peninsula and Scotora. Vol. 1. Edinburgh: Edinburgh University Press.

Richard, A. 1847–50. Tentamen Florae Abyssinicae.

Richards, J. 1994. Some plants of the Asir Mountains. Quart. Bull. Alpine Garden Soc. 62: 34–39.

Schwartz, O. 1939. Flora des tropischen Arabien. Mitt. Inst. Allg. Bot. Hamburg 10: 1–393.

White, F. and J. Léonard. 1991. Phytogeographical links between Africa and Southwest Asia. Fl. Veg. Mundi 9: 229-246.

Wickens, G. E. 1982. Studies in the Flora of Arabia: III. A biographical index of plant collectors in the Arabian Peninsula (including Scotora). Notes Roy. Bot. Gard. Edinburgh 40: 301–330.

Zohary, M., Heller, D., and C. C. Heyn. 1980 and 1983. Conspectus Florae Orinetalis. Fasc. 1 and 2. Jerusalem: Israael Academy of Sciences and Humanities.

Appendix

The following is a list of the flowering plants and ferns collected in the Raydah Nature Reserve and in adjacent and isolated areas in which *Juniperus procera* and juniper woodlands are found in the Asir Mountains

The sequence of families principally follows the Engler system of Dalla Torre and Harms (1900–1907; see Brummitt, 1992). All names printed in bold are accepted names for species and infraspecific taxa; names in italics are synonyms. The numerals in brackets are the collector's field number. Entries with an asterisk are those found in the Raydah Nature Reserve.

Pteridophyta

LYCOPSIDA

Selaginellaceae

Selaginella yemensis (Sw.) Spring in Decne in Arch. Mus. Hist. Nat. 2: 191 (1841).

Tanumah, 2,280 m; Jabal Fayfa, Jizan, 1,820 m.

Type of distribution: SM.

EQUISETOPSIDA

Equisetaceae

Equisetum ramosissimum Desf., Fl. Atlant. 2: 398 (1799).

Between Namas and Tanumah, Tanumah, 2,360 m.

Type of distribution: W.

FILICOPSIDA

Aspleniaceae

Asplenium adiantum-nigrum L., Sp. Pl.: 1081 (1753).

Sughah, Abha, 2,780 m.

Type of distribution: W.

***Asplenium aethiopicum** (Brum. f.) Bech. in Candollea 6: 23 (1935).

Al-Sudah, 2,700–2,730 m; Raydah, Abha, 2,500 m.

Type of distribution: W.

***Asplenium trichomanes** L., Sp. Pl.: 1080 (1753).

Raydah, Abha, 2,500 m.

Type of distribution: W.

***Ceterach officinarum** DC. in Lam. and DC., Fl. Franç., ed. 3, 2: 566 (1805).
Asplenium ceterach L., Sp. Pl.: 1080 (1753).
Al-Sudah, 2,700–2,730 m; Sudah, 2,780 m; Raydah, Abha, 2,500 m.
Type of distribution: W.

Pteridaceae
***Actiniopteris semiflabellata** Pic.-Ser. in Webbia 17: 24 (1962).
Raydah Village, Abha, 1,300–1,420 m; Jabal Fayfa, Jizan, 1,130 m; Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.
Type of distribution: W.

***Adiantum capillus-veneris** L., Sp. Pl.: 1096 (1753).
Raydah, 2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.
Type of distribution: W.

Adiantum incisum Forssk., Fl. Aegypt.-Arab.: 187 (1775).
Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: W.

***Cheilanthes coriacea** Decne. in Arch. Mus. Hist. Nat. 2: 190 (1841).
Raydah, 2,500 m; Raydah Village, Abha, 1,300–1,420 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

Cheilanthes pteridioides (Reichard) C.Chr., Ind. Filic.: 178 (1905).
Al-Sudah, Abha, 2,700–2,730 m; Billasmar, Billasmar, Asir, 2,620 m; Kamer, Asir, 2,720 m; Tanumah, Tanumah, Asir, 2,280 m.
Type of distribution: W.

***Cheilanthes marantae** (L.) Domin in Biblioth. Bot. 85: 133 (1915).
Gymnopteris marantae (L.) Ching
Raydah, 2,500 m; Raydah Conservation Area, Abha, 2,500–2,590 m.
Type of distribution: M.

***Cheilanthes** sp.
Raydah Escarpment, Abha, 2,000 m.

***Pteris dentata** Forssk., Fl. Aegypt.-Arab.: 186 (1775).
Between Namas and Tanumah, Asir, 2,360 m; Raydah, 2,440–2,500 m; Raydah Nature Reserve, Abha,

2,500–2,590 m.

Type of distribution: W.

***Pteris vittata** L., Sp. Pl.: 1074 (1753).

Raydah, 2,440–2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.

Type of distribution: W.

Gymnospermae

PINOPSIDA

Cupressaceae

Juniperus procera Hochst. ex Endl., Syn. Conif.: 26 (1847).

Billasmar, Asir, 2,620–2,700 m; Ghara, Abha, 2,340 m; Kamer, Asir, 2,720 m; between Namas and Tanumah, Tanumah, Asir, 2,550 m; Raydah, 2,300–2,500 m; Raydah Escarpment, 2,850 m; Raydah Village, Abha, 1,500–17,30 m; Sudah, Abha, 2,980 m; Tamniyah, Abha, 2,440–2,550 m; Tanumah, Asir, 2,280–2,500 m; Jabal Fayfa, Jizan, 1,820 m.

Type of distribution: A.

GNETOPSIDA

Ephedraceae

***Ephedra foeminae** Forssk., Fl. Aegypt.-Arab.: 219 (1775).

Al-Abard, Abha, 2,380–2,730 m; Raydah, Abha, 2,300–2,500 m; Sudah, Abha, 2,700 m.

Type of distribution: M, IT, SM.

Ephedra pachyclada Boiss., Fl. Orient. 5: 713 (1884).

Al-Abard, Abha, 2,380 m; Sudah, Abha, 2,680–2,720 m.

Type of distribution: SS.

Ephedra sp.

Al-Abard, Abha, 2,380 m.

Angiospermae
DICOTYLEDINAE

Salicales
Salicaceae
Salix mucronata Thunb., Prodr. Pl. Cap.: 6 (1794).
Salix subserrata Willd., Sp. Pl. 4: 671 (1806).
Ebalah, Billasmar, Asir, 2,620 m; between Namas and Tanumah, Asir, 2,360 m; Zabinan, Abha, 2,630 m.
Type of distribution: W.

Urticales
Ulmaceae
***Celtis africana** Brum. f., Fl. indica: 31 (1768).
Celtis kraussiana Bernh. in Flora 28: 87 (1845).
Between Namas and Tanumah, 2,360 m; Raydah, 2,500 m; Raydah Village, Abha, 1,720–1,850 m; Tanumah, Asir, 2,280 m.
Type of distribution: W.

Moraceae
Dorstenia foetida (Forssk.) Schweinf. in Bull. Herb. Boissier 4: append. 2: 120 (1896).
Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: SM.

***Ficus cordata** Thunb., Ficus: 8 (1786).
subsp. **salicifolia** (Vahl) C.C. Berg in Kew Bull. 43: 82 (1988).
Ficus ambiguum Forssk., Fl. Aegypt.-Arab.: (1775) 219.
Ficus salicifolia Vahl, Symb. Bot. 1: 82, t. 23 (1790).
Raydah, 2,020 m; Raydah Village, Abha, 1,500–1,730 m; Tanumah, Asir, 2,280 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380–1,700 m.
Type of distribution: W.

***Ficus ingens** (Miq.) Miq. in Ann. Mus. Bot. Lugduno-Batavi 3: 288 (1867).
Raydah, Abha, 1,800–2,000 m.
Type of distribution: W.

***Ficus palmata** Forssk., Fl. Aegypt.-Arab.: 179 (1775). Hosni and Hegazy in Candollea 51: 189 (1996).
Al-Abard, Abha, 2,380 m; Al-Sudah, Abha, 2,680–2,720 m; Billasmar, Asir, 2,620 m; Ebalah, Billasmar, Asir, 2,620 m; between Namas and Tanumah, Asir, 2,550 m; Raydah, 2,500 m; Raydah Nature Reserve, Abha, 1,300–2,590 m; Raydah Village, Abha, 1,500–1,850 m; Tamniyah, Asir, 2,440 m; Tanumah, Asir, 2,280–2,420 m; Waji Deli, border of Asir and Jizan, 1,570–1, 690 m; Jabal Fayha, Jizan, 1,200 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,100 m.

Type of distribution: W.

***Ficus sycomorus** L., Sp. Pl.: 1059 (1753).
Raydah Village, Abha, 1,500–1,850 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

***Ficus vasta** Forssk., Fl. Aegypt.-Arab.: 179 (1775).
Raydah, 2,090 m; Raydah Village, Abha, 2,000 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM.

***Ficus** sp.
Raydah Village, Abha, 1.720–1.850 m.

Urticaceae
***Debregeasia saeneb** (Forssk.) Hepper & J.R.I. Wood in Kew Bull. 38: 86 (1983).
Debregeasia bicolor (Roxb.) Wedd. in A.DC., Prodr. 16: 235 (25) (1869).
Debregeasia salicifolia (D.Don) Rendle in Prain, Fl. Trop. Afr. 6 (2): 295 (1916-17).
Between Namas and Tanumah, Asir, 2,550 m; Raydah, Abha, 2,500 m.
Type of distribution: W.

F**orsskaolea tenacissima** L., Opobalsamum 17 (1764). Hosni and Hegazy in Candollea 51: 195 (1996).
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.
Type of distribution: W.

Urtica urens L., Sp. Pl.: 984 (1753).
Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

Santalales
Loranthaceae (incl. Viscaceae)
Oncocalyx glabratus (Engl.) M.G.Gilbert in Nord. J. Bot. 5: 222 (1985).
Al-Abard, Abha, 2,380 m.
Type of distribution: A (rare, previously only collected twice in Saudi Arabia).
Parasitic on *Olea*.

***Oncocalyx schimperi** (Hochst. ex A. Rich.) M.G. Gilbert in Nord. *J.* Bot. 5: 222 (1985).
Loranthus schimperi Hochst. ex A. Rich., Tent. Fl. Abyss. 1: 341 (1847).
Al-Abard, Abha, 2,380 m; Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: A.

Oncocalys sp.
Tamniyah, Asir, 2,440–2,550 m.

Phragmanthera austroarabica A.G. Mill. & J. Nyberg in Edinburgh J. Bot. 51: 37 (1994).
Loranthus rufescens auct. Arab., non DC.
Loranthus regularis auct. Arab., non Sprague.
Al-Sudah, Abha, 2,700 m; Ghara, Abha, 2,340 m; between Ghara and Abha, 2,470 m; between Ghara and Tamniyah, Asir, 2,500 m; Tamniyah, Asir, 2,360–2,550 m; Tanumah, Asir, 2,280 m.
Type of distribution: A (endemic to Saudi Arabia and Yemen).

***Plicosepalus curviflorus** (Benth. ex Oliv.) Tiegh. in Bull. Soc. Bot. France 41: 504 (1894).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Viscum triflorum** DC., Prodr. 4: 279 (1843).
subsp. **nervosum** (Hochst. ex A. Rich.) M. G. Gilbert in Nord. J. Bot. 5: 224 (1985).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

Polygonales
Polygonaceae
Persicaria barbata (L.) H.Hara, Fl. E. Himal.: 70 (1966).
Polygonum barbatum L., Sp. Pl.: 362 (1753).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: W.

Polygonum aviculare L., Sp. Pl.: 362 (1753).
Sudah, Abha, 2,760 m.
Type of distribution: W.

Rumex dentatus L., Mant. Pl. 2: 226 (1771).
Khamis Mushayt, Abha, 2,160 m.
Type of distribution: W.

***Rumex nervosus** Vaih, Symb. Bot. 1: 27 (1790). Hosni and Hegazy in Candollea 51: 190 (1996).
Al-Sudah, Abha, 3,000 m; between Namas and Tanumah, 2,550 m; Raydah Village, Abha, 1,500–1,850 m; Sudah, Abha, 2,980 m; Tanumah, Asir, 2,280 m.
Type of distribution: SM.

Rumex sp.

Khamis Mushayt, Abha, 2,160 m.

Hosni and Hegazy (1996) reported *Rumex vesicarius* L. from Abha, 2,200 m.

Centrospermae

Nyctaginaceae

***Boerhavia diffusa** L., Sp. Pl.: 3 (1753). Hosni and Hegazy in Candollea 51: 189 (1996).

Al-Abard, Abha, 2,380 m; Khamis Mushayt, Abha, 2,164 m; Raydah Village, Abha, 1,500–1,730 m.

Type of distribution: W.

Commicarpus ambiguus Meikle in Kew Bull. 38: 481 (1983).

Al-Mahallah, Abha, 2,350 m.

Type of distribution: SM.

***Commicarpus grandiflorus** (A. Rich.) Standl. in Contr. U. S. Natl. Herb. 18: 101 (1916).

Raydah, 2,440–2,380 m; Raydah Village, Abha, 1,300–1,900 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.

Type of distribution: W.

***Commicarpus plumbagineus** (Cav.) Standl. in Contr. U. S. Natl. Herb. 18: 101 (1916). Hosni and Hegazy in Candollea 51: 190 (1996).

Al-Abard, Abha, 2,380 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Escarpment, 2,200 m; Raydah Village, Abha, 1,500–1,730 m.

Type of distribution: W.

Aizoaceae (incl. Molluginaceae)

Corbichonia decumbens (Forssk.) Exell in *J.* Bot. 73: 80 (1935). Hosni and Hegazy in Candollea 51: 189 (1996).

Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.

Type of distribution: W.

Trianthemum sp.

Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Caryophyllaceae

Hosni and Hegazy (1996) reported *Cometes abyssinica* R.Br. from Aqbet Dalaa (1,000–2,000 m in), *Paronychia arabica* (L.) DC. from Abha (2,200 m), *Spergularia diandra* (Guss.) Heldr. and Sart. from El Darb-Baysh, and *Telephium sphaerospermum* Boiss. from Al Sodah (2,300 m).

Dianthus strictus Banks & Soland. in Russell, Nat. Hist. Aleppo, ed. 2, 2: 252 (1794).

subsp. **sublaevis** D.F. Chamb. in Edinburgh J. Bot. 51: 56 (1994).

Al-Sudah, Abha, 2,800 m; Tamniyah, Asir, 2,360 m.
Type of distribution: A.

Dianthus sp.
Tanumah, Asir, 2,280 m.

***Minuartia filifolia** (Forssk.) Mattfeld in Repert. Spec. Nov. Regni Veg. Beih. 15: 93 (1922). Hosni and Hegazy in Candollea 51: 177 (1996).
Raydah conservation, Abha, 2,500–2,590 m.
Type of distribution: SM.

Polycarpaea repens (Forssk.) Asch. & Schweinf. in Oesterr. Bot. Zeit. 39: 26 (1889).
Tamniyah, Asir, 2,360 m.
Type of distribution: SS.

Silene hockstetteri Rohrb. in Bot. Zeit. 25: 81 (1867).
Sudah, Abha, 2,780–2,950 m.
Type of distribution: SM.

Silene vulgaris (Moench) Garcke, Fl. N. Mitt.-Deutschland ed. 9: 63 (1869).
Sudah, Abha, 2,780 m.
Type of distribution: W.

***Silene** sp.
Raydah Conservation Area, Abha, 2,500–2,590 m.

Chenopodiaceae
Atriplex leucoclada Boiss., Diagn. Pl. Orient., Sér. 1, 2 (12): 95 (1853).
var. **inamonoea** (Aellen) Zohary, Fl. Palaest. 1: 147 (1966).
Atriplex inamonoea Aellen in Bot. Jarhb. Syst. 70: 20 (1939).
Al-Abard, Abha, 2,380 m.
Type of distribution: SS.

var. **turcomanica** (Moq.) Zohary, Fl. Palaest. 1: 147 (1966).
Atriplex leucoclada Boiss. subsp. *turcomanica* (Moq.) Aellen in Bot. Jarhb. Syst. 70: 22 (1939).
Kamer, Asir, 2,720 m.
Type of distribution: SS.

Chenopodium glaucum L., Sp. Pl.: 220 (1753).
Tanumah, Asir, 2,280 m.

Type of distribution: W.

***Chenopodium schraderianum** Schult., Syst. Veg. 6: 260 (1820).
Al-Sudah, Abha, 2,700–2,730 m; Raydah, Abha, 2,500 m; Tanumah, Asir, 2,280 m.
Type of distribution: SM.

***Chenopodium** sp. 1.
Al-Sudah, Abha, 2,700–2,700 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Tanumah, Asir, 2,280 m.

Chenopodium sp. 2.
Khamis Mushayt, Abha, 2,160 m.

Salsola kali L., Sp. Pl.: 222 (1753).
Al-Sudah, Abha, 2,700–2,730 m.
Type of distribution: W.

Suaeda aegyptiaca (Hasselq.) Zohary in *J.* Linn. Soc. Bot. 55: 635 (1957).
Al-Abard, Abha, 2,380 m.
Type of distribution: SS.

Amaranthaceae
Hosni and Hegazy (1996) reported *Pupalia lappacea* (L.) Juss from Aqbet Dalaa.

***Achyranthes aspera** L. var. **sicula** L., Sp. Pl.: 204 (1753). Hosni and Hegazy in Candollea 51: 173 (1996).
Raydah, 2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,500–1,730 m; Tanumah, Asir, 2,280 m.
Type of distribution: SM.

***Aerva javanica** (Burm. f.) Schult., Syst. Veg. 5: 565 (1819). Hosni and Hegazy in Candollea 51: 173 (1996).
Raydah Village, Abha, 1,500–1,730 m; Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.
Type of distribution: W.

***Aerva lanata** (L.) A.L.Juss. in Ann. Mus. Natl. Hist. Nat. 2: 131 (1803).
Raydah Village, Abha, Asir, 1,500–1,730 m.
Type of distribution: W.

***Alternanthera pungens** Kunth in Humb., Bonpl. and Kunth, Nov. Gen. Sp. 2: 206 (1818).
Raydah Village, Abha, Asir, 1,500–1,730 m.
Type of distribution: W.

Amaranthus spinosus L., Sp. Pl.: 991 (1753).
Sudah, Abha, 2,680–2,720 m.
Type of distribution: W.

***Amaranthus** sp.
Raydah Village, Abha, 1,300–1,420 m; Sudah, Abha, Asir, 2,680–2,720 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m; Jabal Fayha, Jizan, 1,200 m.
Hosni and Hegazy (1996) reported *Amaranthus graecizans* L. from Tehama plain.

***Celosia trigyna** L., Mant. Pl. 2: 212 (1771).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Digera muricata** (L.) Mart. in Nova Acta Phys.-Med. Acad. Leop.-Carol. Nat. Cur. 13 (1): 285 (1826).
Digera arvensis Forssk., Fl. Aegypt.-Arab.: 65 (1775).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

Pupalia lappacea (L.) Juss. in Ann. Mus. Natl. Hist. Nat. 2: 132 (1803).
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.
Type of distribution: SS.

Magnoliales
Annonaceae
Annona squamosa L., Sp. Pl.: 537 (1753).
Jabal Fayfa, Jizan, 1,130–1,200 m.
Type of distribution: CN.

Lauraceae
Cassytha filiformis L., Sp. Pl.: 35 (1753).
Jabal Fayfa, Jizan, 1,180 m.
Type of distribution: W.

Ranunculales
Ranunculaceae
Clematis hirsuta Guill. & Perr., Fl. Seneg. Tent. 1: 1 (1831).
Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

***Clematis simensis** Fresen., Beitr. Fl. Abyssin. 2: 267 (1837).

Raydah Village, Abha, 1,760–1,820 m.
Type of distribution: SM.

***Rannunculus multifidus** Forssk., Fl. Aegypt.-Arab.: 102 (1775).
Between Namas and Tanumah, Tanumah, 2,360 m.
Sudah, Abha, 2,700 m; Al-Sudah, Abha, 2,700–2,730 m; Raydah, Abha, 2,500 m.
Type of distribution: W.

Menispermaceae
Cocculus pendulus (*J.* R. & G. Forst.) Diels in Engl. and Prantl, Nat. Pflanzenfam. 4, 94: 237 (1910). Hosni and Hegazy in Candollea 51: 189 (1996).
Al-Mahallah, Abha, 2,350 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.
Type of distribution: SS and SM.

***Tinospora bakis** (A. Rich.) Miers in Hook., Niger Fl.: 215 (1849).
Raydah Village, Abha, Asir, 2,000 m; Waji Deli, border of Asir and Jizan, 340 m.
Type of distribution: SS and SM.

Aristolochiales
Aristolochiaceae
Aristolochia bracteolata Lam., Encycl. 1: 258 (1783).
Wadi Deli, between Abha and Al-Darb, Jizan, 700–1,000 m.
Type of distribution: W.

Guttiferales
Ochnaceae
***Ochna intermis** (Forssk.) Schweinf. in Atti Congr. Bot. Int. Genova (1892): 335 (1893).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

Clusiaceae (Guttiferae, incl. Hypericaceae)
***Hypericum hircinum** L., Sp. Pl.: 784 (1753); N. K. B. Robson in A.G.Miller and T. A. Cope, Fl. Arab. Penin. 1: 331 (1996).
Raydah, 2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha,, 1,760–1,820 m.
Type of distribution: M.
Robson considered the Arabian plants to all be referable to subsp. *majus* (Ation) N. Robson

Hypericum revolutum Vahl, Symb. Bot. 1: 66 (1790).
Al-Sudah, Abha, 2,700–2,730 m; Sudah, Abha, 2,850 m.
Type of distribution: W.

Papaverales

Papaveraceae

***Argemone ochroleuca** Sweet, Brit. Fl. Gard. 3: t. 232 (1829).

Al-Sudah, Abha, 2,960 m; Raydah Village, Abha, 1,560–1,700 m; Sudah, Abha, 2,780 m; Wadi Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Type of distribution: W.

Capparaceae (Capparidaceae).

***Capparis cartilaginea** Decne in Ann. Sci. Nat. Bot., Ser. 2, 3: 273 (1835).

Raydah, Abha, 1,840 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: W.

***Capparis spinosa** L. var. **mucronifolia** (Boiss.) I. C. Hedge & Lamond, Fl. Iran. 68: seven (1970).

Raydah, Abha, 1,800 m.

Type of distribution: SS.

Hosni and Hegazy (1996) reported var. *aegyptica* (Lam.) Boiss. from Aqbet Dalaa (1,000–2,000 m).

Cleome brachycarpa Vahl ex DC., Prodr. 1: 240 (1824). Hosni and Hegazy in Candollea 51: 177 (1996).

Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.

Type of distribution: SS and SM.

***Cleome ramosissima** Webb ex Parl., Fragm. Fl. Aethiop.-Aegypt.: 22 (1854).

Raydah Nature Reserve, Abha, 1,930–2,380 m; Raydah Village, Abha, 1,500–1,730 m.

Type of distribution: SM.

Cleome scaposa DC., Prodr. 1: 239 (1824).

Waji Deli, Between Abha and Al-Darb, Jizan, 1,200–1,240 m.

Type of distribution: SS.

***Cleome** sp.

Raydah Village, Abha.

Maerua olbongifolia (Forssk.) A.Rich., Tent. Fl. Abyss. 1: 32, t. 5 (1847).

Jabal Fayfa, Jizan, 1,180 m.

Type of distribution: SM.

Maerua triphylla A.Rich. var. **calophylla** (Gilg) De Wolf in Kew Bull. 16: 82 (1962).

Jabal Fayfa, Jizan, 1,180–1,370 m.

Type of distribution: SM.

Brassicaceae (Cruciferae).

Arabidopsis thaliana (L.) Heynh. in Holl and Heynh., Fl. Sachsen 1: 538 (1842).

Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: W.

***Arabis alpina** L., Sp. Pl.: 664 (1753).

Raydah, 2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, Abha, 2,400 m.

Type of distribution: W.

***Arabis** sp.

Raydah, Abha, 2,300–2,500 m.

Brassica tournefortii Gouan, Ill. Observ. Bot. 44: t. 20A (1773).

Tanumah, Asir, 2,330 m.

Type of distribution: SS and M.

Capsella bursa-pastoris (L.) Medik., Pfl.-Gatt.: 85 (1792).

Sughah, Abha, 2,780 m; Tanumah, Asir, 2,280 m.

Type of distribution: W.

Diplotaxis harra (Forssk.) Boiss., Fl. Orient. 1: 388 (1867).

Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Type of distribution: SS.

Eruca sativa Mill., Gard. Dict. ed. 8: 1 (1768).

Al-Sudah, Abha, 2,700–2,730 m.

Type of distribution: W.

Erucastrum arabicum Fisch. & C.A. Mey., Ind. Sem. Hort. Petrop. 5: 35 (1838).

Tanumah, Asir, 2,280 m.

Type of distribution: W.

Farsetia burtoniae Oliv. in Hook., Icon. Pl. 14: t. 1310 (1880).

Sudah, Abha, 2,780 m.

Type of distribution: SS.

Farsetia sp.

Sudah, Abha, 2,680–2,720 m; Tanumah, Asir, 2,420 m.

Hosni and Hegazy (1996) reported *Farsetia longisiliqua* Decne. from Abha, 2,200 m and other places.

Lepidium africanum (Burm. f.) DC., Syst. Nat. 2: 552 (1821).
Sudah, Abha, 2,760 m.
Type of distribution: SM.

Raphanus raphanistrum L., Sp. Pl.: 669 (1753).
Al-Sudah, Abha, 2,800 m; Tanumah, Asir, 2,330 m.
Type of distribution: W.

***Sisymbrium erysimoides** Defl., Fl. Atlant. 2: 84 (1798).
Raydah, 2,440–2,380 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Jabal Fayfa, Jizan, 1,130 m, 1,820 m.
Type of distribution: SS and M.

Sisymbrium irio L., Sp. Pl.: 659 (1753).
Al-Sudah, Abha, 2,800 m.
Type of distribution: W.

Resedaceae
Caylusa hexagyna (Forssk.) M.L. Green is reported from Abha, 2,200 m by Hosni and Hegazy (1996).

***Ochradenus baccatus** Delile, Fl. Aegypt. Ill.: 63 (1813).
Between Abha and Ghara', Abha, 2,470 m; between Ghara and Tamniyah, Asir, 2,500 m; Raydah, Abha, 1,840 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: SS and SM.

Reseda lutea L., Sp. Pl.: 449 (1753).
Al-Sudah, Abha, 2,850 m; Sudah, Abha, 2,850 m.
Type of distribution: M.

Reseda sphenocleoides Defl. in Bull. Soc. Bot. France 42: 298 (1895). Hosni and Hegazy in Candollea 51: 191 (1996).
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,380 m.
Type of distribution: SM.

Rosales
Crassulaceae
***Crassula alba** Forssk., Fl. Aegypt.-Arab.: 60 (1775).
Raydah conservation, Abha, 2,500–2,590 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM.

Tillaea schimperi (C.A.Mey.) M.G.Gilbert, H. Ohba & K.T. Fu in Novon 10: 366 (2000).
Crassula schimperi C.A. Mey. in Fisch., C.A. Mey. & Avé-Lallemant, Index Sem. Hort. Petrop. 8: 56 (1842).
Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

***Kalanchoe citrina** Schweinf. in Bull. Herb. Boissier 4: append. 2: 199 (1896).
Raydah Village, Abha, 1,640 m.
Type of distribution: SM.

***Kalanchoe deficiens** (Forssk.) Asch. and Schweinf. in Mém. Inst. Égypt. 2: 79 (1887).
var. **glabra** Raadts in Willdenowia 18: 423 (1989).
Raydah Village, Abha, 1,640 m.
Type of distribution: A.

***Kalanchoe glaucescens** Britten in Oliv., Fl. Trop. Afr. 2: 393 (1871).
Raydah Village, Abha, 1,640 m.
Type of distribution: SM.

***Kalanchoe laciniata** (L.) DC., Pl. Hist. Succ. 2: 100 (1802).
Raydah Village, Abha, 1,640 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

***Kalanchoe lanceolata** (Forssk.) Pers., Syn. Pl. 1: 446 (1805).
Raydah Village, Abha, 1,640 m.
Type of distribution: W.

Umbilicus horizontalis (Guss.) DC., Prodr. 3: 400 (1828).
Tanumah, Asir, 2,280 m.
Type of distribution: M and SS.

***Umbilicus rupestris** (Salisb.) Dandy in Riddelsdell, Hedley and Price, Fl. Gloucestershire: 611 (1948).
Raydah conservation, Abha, 2,500–2,590 m.
Type of distribution: M.

Pittosporaceae
***Pittosporum viridiflorum** Sims in Bot. Mag.: t. 1684 (1814).
subsp. **arabicum** Cufod. in Repert. Spec. Nov. Regni Veg. 55: 72 (1952).
Pittosporum viridiflorum Sims in Bot. Mag. 41: t. 1684 (1815).
Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, Abha, 2,400 m.
Type of distribution: SS.

Rosaceae

Malus sylvestris Mill., Gard. Dict., ed. 8: No. 1 (1768).

Sudah, Abha, Asir, 2,680–2,720 m.

Type of distribution: CN.

***Rosa abyssinica** Lindley, Ros. Monogr.: 116, t. 13 (1820). Hosni and Hegazy in Candollea 51: 191 (1996).

Rosa moschata Herrm. var. *abyssinica* (Lindley) Crépin in Bull. Roy. Soc. Bot. Belgique 28(2): 47 (1889).

Rosa bottaiana Boulenger in Verh. Naturf. Ges. Basel 44: 280 (1933).

Billasmar, Asir, 2,800 m; between Namas and Tanumah, Asir, 2,360–2,550 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Escarpment, Abha, 2,800 m; Tamniyah, Asir, 2,440–2,550 m; Tanumah, Asir, 2,280–2,500 m.

Type of distribution: SM.

***Rubus asirensis** D. F. Chamb. in Edinburgh *J.* Bot. 51: 57 (1994).

Raydah, Abha, 2,300–2,500 m; between Namas and Tanumah, Asir, 2,360 m; Tanumah, Asir, 2,280 m.

Type of distribution: Uncertain (endemic).

Fabaceae (Leguminosae).

Hosni and Hegazy (1996) reported *Argyrolobium arabicum* (Decne.) Jaub. and Spach from Abha, 2,200 m, and also *A. confertum* Polhill from El Sodah, 2,300 m.

Acacia abyssinica Hochst. ex Benth. in Hook., London *J.* Bot. 5: 97 (1846).

var. **macroloba** Schweinf. in Bull. Herb. Boissier 4, App. 2: 212 (1896).

Acacia johnwoodii Boulos in Kew Bull. 50: 327 (1995).

Jabal Fayha, Between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: SM.

***Acacia asak** (Forssk.) Willd., Sp. Pl. 4: 1077 (1806). Hosni and Hegazy in Candollea 51: 185 (1996).

Raydah Village, Abha, 1,560–1,700 m; Wadi Deli, Between Abha and Al-Darb, Jizan, 940−1,200 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,100 m.

Type of distribution: SM.

***Acacia etbaica** Schweinf. in Linnaea 35: 330, t. VII, VIII (1867-68).

subsp. **uncinata** Brenan in Kew Bull. 1957: 91 (1957).

Raydah Village, Abha, 1,500–1,730 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m; Jabal Fayha, Jizan, 1,200 m.

Type of distribution: SS.

Subsp. *etbaica* is reported from Abha–El Sodah road, 2,300 m by Hosni and Hegazy (1996).

Acacia gerrardii Benth. in Trans. Linn. Soc. Lond. 30: 508 (1875).

A. gerrardii Benth. subsp. *negevensi*s Zohary in Israel *J.* Bot. 13: 39 (1964). Chaudary, Fl. Saudi Arabia 1: 604 (1999).

Al-Mahallah, Abha, 2,350 m.
Type of distribution: SS.

***Acacia origena** Hunde in Nord. *J.* Bot. 2: 337, f. 1 (1982).
Billasmar, Asir, 2,800 m; Ghara, Abha, 2,340 m; Raydah Village, Abha, 1,760–1,820 m; Al-Sudah, Abha, 2,700 m; Sudah, Abha, 2,980 m; Tanumah, Asir, 2,420–2,500 m.
Type of distribution: SM.
Chaudhary (1999) noted that this species at one time formed an extensive community with *Juniperus procera* on the eastern slopes of the Asir Mountains in the Abha region, and extended up to about 2,700 m.

Acacia seyal Delile, Fl. Egypt. Ill.: 286, t. 52 f. 2 (1813).
Jabal Fayfa, Jizan, 1,600 m.
Type of distribution: SS.

Acacia sp.
Jabal Fayfa, Jizan, 1,200–1,370 m.
Hosni and Hegazy (1996) recorded *Acacia saligna* Wendl. from Abha, 2,200 m, and *A. sieberana* DC. from El Sodah, 2,300 m. Boulos (1995) recorded *A. oerfota* (Forssk.) Schweinf. var. *brevifolia* Boulos from Asir, Wadi Manfah, 50 km NNW of Najran.

Anagyris foetida L., Sp. Pl.: 374 (1753).
Billasmar, Asir, 2,620 m; between Namas and Tanumah, Asir, 2,550 m; Sudah, Abha, 2,850 m.
Type of distribution: M and IT.

Astragalus atropilosulus (Hochst.) Bunge in Mém. Acad. Imp. Sci. Saint Pétersburg, Sér. 7, 25: 4 (1869). Hosni and Hegazy in Candollea 51: 187 (1996), as *A. abyssinicus* Steud. ex A. Rich., Tent. Fl. Abyss. 1: 193 (1847).
Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM.
Astragalus sparsus Del. and Decne., *A. tribuloides* var. *minutus* (Boiss.) Boiss., and *A. vogelii* (Webb) Bornm. are reported from Abha, 2,200 m by Hosni and Hegazy (1996).

Cadia purpurea (Picciv.) Aiton, Hort. Kew. 3: 492 (1789).
Raydah, 1,930–2,090 m; Raydah Village, Abha, 1,300–1,730 m.
Type of distribution: SM.

Crotalaria sp.
Between Namas and Tanumah, Asir, 2,360 m.

Desmodium gangeticum (L.) DC., Prodr. 2: 327 (1825).
Jabal Fayha, Jizan, 1,200 m.

Type of distribution: W.

***Indigofera amorphoides** Jaub. & Spach, Ill. Pl. Orient. 5: 93, t. 483 (1856).
Raydah Village, Abha, 1,300–1,700 m; Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: SM.

***Indigofera argentea** Burm.f., Fl. Indica: 171 (1768).
Raydah Village, Abha, 1,500–1,730 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: SS.

***Indigofera colutea** (Brum. f.) Merr. in Phillip. *J.* Sci. 19: 355 (1921).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

Indigofera spiniflora Hochst. & Steud. ex Boiss., Fl. Orient. 2: 190 (1872), in obs.
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.
Type of distribution: SS.

***Indigofera spinoa** Forssk., Fl. Aegypt.-Arab.: 137 (1775). Hosni and Hegazy in Candollea 51: 188 (1996).
Raydah Village, Abha, 1,560–1,700 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.
Type of distribution: SS.

Indigofera sp.
Al-Mahallah, Abha, 2,350 m.
Indigofera arabica Jaub. and Spach is reported from Abha, 2,200 m by Hosni and Hegazy (1996).

Lablab purpureus (L.) Sweet, Hort. Brit. ed. 1: 481 (1827).
Dolichos lablab L., Sp. Pl.: 725 (1753).
Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: W.

Lathyrus pratensis L., Sp. Pl.: 733 (1753).
Al-Sudah, Abha, 2,700–2,730 m; Sughah, Abha, 2,780 m.
Type of distribution: SS and IT.

Lotus sp.
Jabal Fayfa, Jizan, 1,180 m.

Medicago sp.
Raydah Village, Abha, 1,300–1,420 m.

Medicago laciniata var. *brachycantha* Boiss. and *M. sativa* L. is reported from Abha, 2,200 m by Hosni and Hegazy (1996).

Melilotus albus Medik., Vorles. Churpf. Phys.-Öcon. Ges. 2: 382 (1787).
Sudah, Abha, 2,760 m.
Type of distribution: W.

Prosopis juliflora (Swartz) DC., Prodr. 2: 447 (1825).
Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: CN, native of America and the West Indies, and planted widely in Saudi Arabia.

***Rynchosia malacophylla** (Spreng.) Bojer, Hortus Maurit.: 104 (1837).
Raydah, Abha, 2,300–2,500 m.
Type of distribution: SS and SM.

***Rhynchosia** sp.
Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Senna holosericea (Fresen) Greuter in Willdenowia 15: 429 (1986).
Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: SS.

***Senna italica** Mill., Gard. Dict. ed. 8: No. 2 (1768). Hosni and Hegazy in Candollea 51: 188 (1996).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: SS.

***Senna occidentalis** (L.) Link, Handbuch 2: 140 (1831).
Raydah Village, Abha, 1,300–1,420 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: W.

Tamarindus indica L., Sp. Pl.: 34 (1753).
Jabal Fayha, Jizan, 1,180 m.
Type of distribution: W.

Tephrosia purpurea (L.) Pers., Syn. Pl. 2: 329 (1807). Hosni and Hegazy in Candollea 51: 188 (1996), as subsp. *apollinea* (Del.) H.Hosni & El Karemy.
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.
Type of distribution: TA and SS.

Tephrosia sp.

Sudah, Abha, 2,700 m.

Vicia sativa L. var. **angustifolia** (L. ex Reichard) Wahlenb., Fl. Carpat. Princ.: 218 (1814).
Sudah, Abha, 2,760 m.
Type of distribution: W.

Geraniales
Geraniaceae
Erodium cicutarium (L.) L'Hér. ex Aiton, Hort. Kew. 2: 414 (1789). Hosni and Hegazy in Candollea 51: 183 (1996).
Sudah, Abha, 2,700–2,780 m.
Type of distribution: W.
Hosni and Hegazy (1996) also recorded *Erodium neuradifolium* Del. ex Godr. from Abha–El Sodah road, 2,300 m.

Geranium arabicum Forssk., Fl. Aegypt.-Arab.: 124 (1775).
Sudah, Abha, 2,700–2,780 m.
Type of distribution: SM.

***Geranium robertianum** L., Sp. Pl.: 681 (1753).
Raydah, Abha, 2,500 m.
Type of distribution: W.

Geranium sp.
Al-Sudah, Abha, 2,700–2,730 m.

***Monsonia heliotropoides** (Cav.) Boiss., Fl. Orient. 1: 897 (1867).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: SM.

***Pelargonium multibracteatum** Hochst. ex A. Rich., Tent. Fl. Abyss. 1: 118 (1847).
Raydah Village, Abha, 1,500 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: SM.

Zygophyllaceae
***Fagonia indica** Burm. f., Fl. Indica: 102 (1768). Hosni and Hegazy in Candollea 51: 196 (1996).
Between Abha and Ghara, Abha, 2,470 m; between Ghara and Abha, 2,470 m; Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: SS.

Peganum harmala L., Sp. Pl.: 444 (1753). Hosni and Hegazy in Candollea 51: 195 (1996).
Al-Abard, Abha, 2,380 m; Billahamar, Asir, 2,160–2,610 m.
Type of distribution: W.

*__Tribulus__ sp.
Raydah Village, Abha, 1,500–1,730 m.

Euphorbiaceae
*__Acalypha fruticosa__ Forssk., Fl. Aegypt.-Arab.: 161 (1775).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

*__Acalypha indica__ L., Sp. Pl.: 1003 (1753).
Raydah Village, Abha, 1,300–1,730 m; Wadi Deli, between Abha and Al-Darb, Jizan, 1,000–1,020 m.
Type of distribution: W.

*__Acalypha lanceolata__ Willd., Sp. Pl. 4: 524 (1805).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

*__Acalypha__ sp.
Raydah Village, Abha, 1,500–1,730 m.

__Andrachne aspera__ Spreng., Novi Provent.: 5 (1819).
Al-Abard, Abha, 2,380 m; Sudah, Abha, 2,780 m.
Type of distribution: SS and IT.
Hosni and Hegazy (1996) recorded *Andrachne telephioides* L. from Abha, 2,200 m.

__Chrozophora oblongifolia__ (Delile) A. Juss. ex Spreng., Syst. Veg., ed. 16, 3: 850 (1826).
Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,240 m.
Type of distribution: SS.

*__Clutia myricoides__ Jaub. & Spach, Ill. Pl. Orient. 5: 73, t. 456, 466 (1855). Hosni and Hegazy in Candollea 51: 182 (1996).
Al-Mahallah, Abha, 2,350 m; Al-Sudah, Abha, 2,700–2,730 m; Aydah Village, Abha, 1,500–1,730 m; Kamer, Asir, 2,720 m; Raydah, 2,090–2,440 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,300–1,730 m; Sudah, Abha, 2,680–2,720 m; Tamniyah, Asir, 2,440–2,550 m; Tamnyah, Abha, 2,440–2,550 m; Tanumah, Asir, 2,280– 2,330 m.
Type of distribution: SM.

*__Euphorbia granulata__ Forssk., Fl. Aegypt.-Arab.: CXII and 94 (1775).
var. __glabrata__ (Gay) Boiss.
Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: SS.

Euphorbia helioscopia L., Sp. Pl.: 459 (1753).
Sudah, Abha, 3,050 m.
Type of distribution: W.

***Euphorbia indica** Lam., Encycl. 2: 423 (1788).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

***Euphorbia schimperiana** Hochst. ex Scheele in Linnaea 17: 344 (1843). Hosni and Hegazy in Candollea 51: 178 (1996), as subsp. *schimperiana*.
Between Namas and Tanumah, Asir, 2,550 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Escarpment, Abha, 2,800 m; Sudah, Abha, 2,850– 2,980 m.
Type of distribution: SM.

Euphorbia sp.
Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

***Flueggea leucopyrus** Willd., Sp. Pl. 4: 757 (1806).
Securinega leucopyrus (Willd.) Müll.Arg. in DC., Prodr. 15(2): 451 (1866).
Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: W.

***Securinega virosa** (Roxb. ex Willd.) Baill. in Adansonia 6: 334 (1886).
Flueggea virosa (Roxb. ex Willd.) Baill., Études Gén. Euphorb.: 593 (1853).
Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: W.

Jatropha glauca Vahl, Symb. Bot. 1: 78 (1790). Hosni and Hegazy in Candollea 51: 183 (1996).
Wadi Deli, between Abha and Al-Darb, Jizan, 700–1,000 m.
Type of distribution: SM.

***Ricinus communis** L., Sp. Pl.: 1007 (1753).
Raydah Village, Abha, 1,500–1,730 m; Tanumah, Asir, 2,420 m.
Type of distribution: SS.

Rutales
Rutaceae
Ruta chalepensis L., Mant. Pl.: 69 (1767).

Al-Sudah, Abha, 2,700–2,730 m; Tanumah, Asir, 2,500 m.
Type of distribution: M.

***Teclea nobilis** Delile in Ann. Sci. Nat. Paris, sér. 2, 20: 90, t. 1, f. 1 (1843).
Raydah, 1,930–2,090 m; Raydah Nature Reserve, Abha, 2,100–2,300 m; Raydah Village, Abha, 1,720–1,850 m.
Type of distribution: TA.

Meliaceae
Trichilia emetica Vahl, Symb. Bot. 1: 34 (1790).
Jabal Fayha, Jizan, 1,200 m.
Type of distribution: TA.

Polygalaceae
Polygala schwartziana Paiva in Anales Jard. Bot. Madrid 45: 155 (1988).
Polygala subaphylla O. Schwartz in Mitt. Inst. Bot. Hamburg 10: 132 (1939), nom. illegit.
Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: SM.

***Polygala tinctoria** Vahl, Symb. Bot. 1: 50 (1790).
Raydah Village, Abha, 1,720–1,850 m.
Type of distribution: SM.

Polygala sp.
Between Abha and Khamis Mushayt, Abha, 2,200 m; Billasmar, Asir, 2,800 m;
Jabal Fayfa, Jizan, 1,180 m.
Hosni and Hegazy (1996) reported *Polygala abyssinica* R.Br. ex Fresen. from Abha–El Sodah road, 2,300 m.

Sapindales
Anacardiaceae
***Pistacia falcata** Becc. ex Martelli, Fl. Bogos.: 25 (1886).
Raydah Nature Reserve, 2,100; Raydah, Abha, 2,300–2,500 m.
Type of distribution: SM.

***Rhus retinorrhoea** Steud. ex A. Rich., Tent. Fl. Abyss. 1: 142 (1847).
Kamer, Asir, 2720 m; between Namas and Tanumah, Asir, 2,360 m; Raydah, 2,300–2,500 m; Raydah Village, Abha, 1,760–1,820 m; Tamniyah, Asir, 2,440 m.
Type of distribution: SM.

Sapindaceae
***Dodonaea angustifolia** L. f., Suppl.: 218 (1782).

Dodonaea viscosa (L.) Jacq.: Hosni and Hegazy in Candollea 51: 192 (1996).

Al-Sudah, Abha, 2,960 m; Billasmar, Asir, 2,620 m; between Namas and Tanumah, Asir, 2,550 m; Raydah Escarpment, Abha, 2,800–2,850 m; Tamniyah, Asir, 2,440–2,550 m; Tanumah, Asir, 2,280 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: W.

Celastrales

Celastraceae

Maytenus heterophylla (Eckl. & Zeyh.) N. Robson in Bol. Soc. Brot., ser. 2, 39: 17 (1965).

Tamniyah, Asir, 2,440–2,550 m.

Type of distribution: TA.

***Maytenus parviflora** (Vahl) Sebsebe in Symb. Bot. Upsal. 25: 63 (1985).

Between Namas and Tanumah, Asir, 2,550 m; Raydah, 1,930 m; Raydah Village, Abha, 1,760–1,820 m; Tanumah, Asir, 2,280 m.

Type of distribution: SM.

Maytenus undata (Thunb.) Blakelock in Kew Bull. 1956: 237 (1956).

Jabal Fayha, Jizan, 1,180 m.

Type of distribution: SM.

***Maytenus** sp.

Raydah Escarpment, Abha, 2,400 m.

Rhamnales

Rhamnaceae

Rhamnus oleoides L., Sp. Pl., ed. 2 : 279 (1762).

Rhamnus lycioides L. subsp. *oleoides* (L.) Jahand. & Maire.

Al-Sudah, Abha, 2,700–2,730 m; Billasmar, Asir, 2,800 m; Sudah, Abha, 2,700 m; Tamniyah, Asir, 2,440 m; Tanumah, Asir, 2,280 m.

Type of distribution: M.

***Sageretia thea** (Osbeck) M.C.Johnst. in J. Arnold Arb. 49: 378 (1968).

var. **bornmuelleri** (Schneid) M.C. Johnst. ex H. Hara in Hara and Williams, Enum. Flow. Nepal 2: 92 (1979).

Raydah, 2,300–2,500 m; Raydah Village, Abha, 1,500–1,730 m; Tamniyah, Asir, 2,440–2,550 m.

Type of distribution: W.

Ziziphus spina-chisti (L.) Desf., Fl. Atlant. 1: 201 (1798).

*var. **spina-chisti**

Raydah Village, Abha, 1,500–1,820 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: W.

*var. **inermis** Boiss.
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Ziziphus** sp.
Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, Jizan, 1,200 m.

Vitaceae
***Cissus rotundifolius** (Forssk.) Vahl, Symb. Bot. 3: 19 (1790). Hosni and Hegazy in Candollea 51: 195 (1996).
Raydah Village, Abha, Asir, 1,500–1,730 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.
Type of distribution: TA.

***Cyphoste mma digitatum** (Forssk.) Desc. in Nat. Monspel., Sér. Bot., Fasc. 18: 220 (1967).
Cissus digitata (Forssk.) Lam., Tab. Encycl. 1: 322 (1791).
Raydah Village, Abha, 1,500–1,930 m; Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: SM.

Malvales
Tiliaceae
***Grewia tembensis** Fresen. in Mus. Senckenberg. 2: 158 (1837).
Raydah, 2,090 m; Raydah Village, Abha, 1,300–1,820 m.
Type of distribution: SM.

***Grewia velutina** (Forssk.) Lam., Encycl. 3: 45 (1789).
Wadi Deli, between Abha and Al-Darb, Jizan, 940–1020 m; Raydah, 1,800–2,000 m; Raydah Village, Abha, 1,300–1,700 m; Jabal Fayha, Jizan, 1,180 m.
Type of distribution: SS (endemic).

***Grewia villosa** Willd. in Nova Acta Not. Cur. Berl. 4: 205 (1803). [Ges. Nat. Fr. Neue Schr. 4: 205]. Hosni and Hegazy in Candollea 51: 194 (1996).
Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: SS.

Grewia sp.
Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.

Malvaceae
***Abutilon bidentatum** Hochst. ex A. Rich., Tent. Fl. Abyss. 1: 68 (1847).

Raydah, Abha, 1,840 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m; Waji Deli, between Abha and Al-Darb, Jizan, 1.100 m.
Type of distribution: SS.

Abutilon figarianum Webb, Fragm. Fl. Aeth.-arab.: 52 (1854).
Al-Mahallah, Abha, 2,350 m.
Type of distribution: SM.

***Abutilon hirtum** (Lam.) Sweet, Hort. Brit., ed. 1: 53 (1826).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

***Abutilon** sp.
Raydah Village, Abha, 1,300–1,420 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,100 m.

***Fioria dictyocarpa** (Hochst.) Mattei in Bot. R. Orto Bot. Palermo 2: 74 (1917).
Raydah, 1,800 m; Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: TA.

***Hibiscus deflersii** Schweinf. ex Cufod. in Ann. Naturh. Mus. Wien 56: 36 (1948).
Raydah Village, Abha, 1,300–1,850 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: SM.

***Hibiscus micranthus** L. f., Suppl.: 308 (1781).
Bombyx micranthus (L.f.) Riedl in Rech. f., Fl. Iranica 120: 34 (1976).
Raydah, Abha, 2,090 m.
Type of distribution: W.

Hibiscus aristaevalvis Garcke in Bot. Zeit. 7: 849 (1849).
Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: W.

Hibiscus sp.
Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

***Malva parviflora** L., Demons. Pl. Hort. Ups.: 18 (1753).
Raydah conservation, Abha, 2,500–2,590 m; Sudah, Abha, 2,700 m.
Type of distribution: M and IT.

Sterculiaceae

***Dombeya torrida** (J.F.Gmel.) P. Bamps in Bull. Jard. Bot. Brux. 32: 170 (1962).
Raydah Escarpment, 2,000 m; Raydah Village, Abha, 1,400–1,700 m.
Type of distribution: TA.

Melhania phillipsiae Baker f. in *J.* Bot. 1898: 4 (1898).
Waji Deli, between Abha and Al-Darb, Jizan, 940–1,380 m; Jabal Fayfa, Jizan, 1,130 m.
Type of distribution:

***Melhania velutina** Forssk., Fl. Aegypt.-Arab.: 64 (1775).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

***Melhania** sp.
Raydah Village, Abha, 1,300–1,420 m.

Thymelaeaceae
Richards (1994) reported *Gnidia somalensis* (Franch.) Gilg from the Asir Mountains.

Violales
Violaceae
***Hybanthus enneaspermus** (L.) F. Muell. in Fragm. 10: 81 (1876-77).
Raydah Village, Abha, 1,500–1,820 m.
Type of distribution: SS.

Viola sp.
Ghara, Abha, 2,340 m.

Tamaicaceae
Tamarix sp.
Khamis Mushayt, Abha, 2,164 m.
Tamarix arborea (Sieb. ex Ehrenb.) Bunge is reported from Abha, 2,200 m by Hosni and Hegazy (1996).

Cucurbitales
Cucurbitaceae
Citrullus colocynthis (L.) Schrad. in Linnaea 12: 414 (1838). Hosni and Hegazy in Candollea 51: 182 (1996).
Tanumah, Asir, 2,420 m; Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.
Type of distribution: W.

***Coccinea grandis** (L.) Voigt, Hort. Suburb. Calc.: 59 (1845).
Raydah, 2,020 m; Raydah Village, Abha, 1,300–1,730 m.

Type of distribution: W.

***Corallocarpus schimperi** (Naudin) Hook. f. in Oliv., Fl. Trop. Afr. 2: 567 (1871).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Ctenolepis cerasiformis** (Stocks) Hook. f. in Oliv., Fl. Trop. Afr. 2: 558 (1871).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

***Cucumis prophetarum** L., Cent. Pl. 1: 32 (1755). Hosni and Hegazy in Candollea 51: 182 (1996), as subsp. dissectus (Naud.) C. Jeffrey.
Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: W.

***Cucumis pustulatus** Hook. f. in Oliv., Fl. Trop. Afr. 2: 544 (1871).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Kedrostis** sp.
Raydah Village, Abha, 1,300–1,730 m.

***Zehneria scabra** (L.) Sond. in Fl. Cap. 2: 486 (1862).
Al-Sudah, Abha, 2,700 m; between Namas and Tanumah, Asir, 2,550 m; Raydah conservation, 2,500–2,590 m; Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

Myrtiflorae
Combretaceae
Terminalia brownii Fresen in Mus. Senckenberg. 2: 152, t.9 f. 1 (1837).
Jabal Fayha, Jizan, 1,180–1,370 m.
Type of distribution: SM.

Onagraceae
***Epilobium hirsutum** L., Sp. Pl.: 347 (1753).
Al-Sudah, Abha, 2,700–2,730 m; between Namas and Tanumah, Asir, 2,360 m; Raydah, Abha, 2,500–2,700 m.
Type of distribution: W.

Umbelliflorae
Apiaceae (Umbelliferae).

A mmi majus L., Sp. Pl.: 243 (1753).

Between Namas and Tanumah, Asir, 2,360 m; Sudah, Abha, 2,780 m; Tanumah, Asir, 2,420 m.

Type of distribution: W.

Apium nodifolrum (L.) Lag., Amen. Nat. Españ. 1, 2: 101 (1821).

Al-Sudah, Abha, 2,700–2,730 m.

Type of distribution: W.

Bupleurum gaeradii All., Auct. Syn. Meth. Stirp. Hort. Taurin: 81 (1773).

Between Namas and Tanumah, Asir, 2,360 m.

Type of distribution: W.

Pimpinella hirtella (Hochst.) A. Rich., Tent. Fl. Abyss. 1: 323 (1848).

Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m; Jabal Fayfa, Jizan, 1,820 m.

Type of distribution: SM.

SYMPETALAE

Ericales

Ericaceae

Erica arborea L., Sp. Pl.: 353 (1753).

Billasmar, Asir, 2,800 m; Sudah, Abha, 2,950 m; Tanumah, Asir, 2,500–2,800 m; Tanumah, Asir, 2,280 m.

Type of distribution: M.

Primulales

Myrsinaceae

***Maesa lanceolata** Forssk., Fl. Aegypt.-Arab.: CVI and 66 (1775).

Raydah, 2,380–2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, 2200 m; Raydah Village, Abha, 1,500–1,850 m; Tamniyah, Asir, 2,440–2,550 m; Tanumah, Asir, 2,330 m.

Type of distribution: TA.

Primulaceae

Richards (1994) reported *Primula verticillata* Forssk. from the Asir Mountains with a photograph.

***Anagallis foemina** Mill., Gard. Dict. ed. 8: No. 2 (1768).

Raydah, 2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.

Type of distribution: W.

***Samolus valerandi** L., Sp. Pl.: 171 (1753).

Raydah, Abha, 2,440–2,380 m.

Type of distribution: W.

Ebenales

Ebenaceae

***Euclea schimperi** (A.DC.) Dandy in Andrews, Fl. Pl. Anglo-Egypt. Sudan 2: 370 (1952).

Raydah, 2,000 m; Raydah Village, Abha, 1,500–1,730 m.

Type of distribution: SM.

Oleales

Oleaceae

***Jasminum grandiflorum** L., Sp. Pl., ed. 2: 9 (1762).

Raydah, 2,440–2,380 m; Raydah Nature Reserve, Abha, 2,100–2,590 m; Tamniyah, Asir, 2,440–2,550 m; Tanumah, Asir, 2,330 m; Jabal Fayfa, Jizan, 1,180 m.

Type of distribution: SS.

***Olea europaea** L., Sp. Pl.: 8 (1753).

subsp. **cuspidata** (Wall. ex G. Don) Ciferri in L'Olivicoltore 19(5): 96 (1942). Green and Wickens in Kit Tan, Davis

and Hedge Festschrift: 287 (1989).

Olea ferruginea Royle, Ill. Bot. Himal.: 267, t. 65, f.1 (1835).

Billahamar, Asir, 2650 m; Raydah, 2,300–2,500 m; Raydah Escarpment, Abha, 2,400 m; Tamniyah, Asir, 2,440 m; Tanumah, Asir, 2,330 m; Jabal Fayfa, Jizan, 1,130 m.

Type of distribution: W.

Gentianales

Gentianaceae

Swertia polynectaria (Forssk.) Gilg in Engl. and Prantl, Nat. Pflanzenfam. IV, 2: 88 (1895).

Sudah, Abha, 2,950 m.

Type of distribution: SM.

Apocynaceae

Acokanthera schimperi (A. DC.) Schweinf. in Boll. Soc. Afr. Italia 10: 12 (1891).

Tamniyah, Asir, 2,440 m.

Type of distribution: SM.

***Adenium obesum** (Forssk.) Roem. and Schult., Syst. Veg. 4: 411 (1819).

Khamis Mushayt, 2,160 m; Raydah Village, Abha, 1,560–1,700 m; Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Type of distribution: TA.

***Carissa edulis** Vahl, Symb. Bot. 1: 22 (1790).

Raydah, 2,300–2,500 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Village, Abha, 1,720–1,850 m.

Type of distribution: SS; TA.

Asclepiadaceae

Calotropis *procera* (Aiton) W. T. Aiton, Hortus Kew. 2: 78 (1810). Hosni and Hegazy in Candollea 51: 174 (1996).

Tanumah, Asir, 2,330 m; Jabal Fayfa, Jizan, 1,180 m; Waji Deli, between Abha and Al-Darb, Jizan, 420–1,380 m.

Type of distribution: SS.

***Caralluma penicillatus** (Defl.) N.E. Br., Gard. Chron., ser. 3, 12: 370 (1892). Hosni and Hegazy in Candollea 51: 174 (1996).

Boucerosia penicillata Defl., Voy. Yemen: 169 (1889).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: SS.

Gomphocarpus fruticosus (L.) R.Br. in Mém. Wern. Nat. Hist. Soc. 1: 38 (1810).

Raydah, 1,800–2,090 m; Raydah Village, Abha, 1,500–1,820 m; Sudah, Abha, 2,680–2,720 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: CN.

***Gomphocarpus sinaicus** Boiss., Diagn. Pl. Orient., ser. 1, 11: 80 (1849). Hosni and Hegazy in Candollea 51: 174 (1996).
Al-Mahallah, Abha, 2,350 m; Raydah, Abha, 1,930 m; Sudah, Abha, 2,780 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m; Tanumah, Asir, 2,280– 2,330 m.
Type of distribution: SS.

Kanahia laniflora (Forssk.) R. Br. in Mém. Wern. Soc. 1: 40 (1810).
Al-Mahallah, Abha, 2,350 m; Tamniyah, Asir, 2,440 m.
Type of distribution: TA.

***Pergularia daemia** (Forssk.) Chiov. in Res. Sci. Miss. Stefan.-Paoli Somal. Ital. 1: 115 (1916).
Raydah Village, Abha, 1,300–1,730 m.
Type of distribution: SS.

Pergularia tomentosa L., Mant. Pl.: 53 (1767).
Al-Mahallah, Abha, 2,350 m.
Type of distribution: SS.

***Periploca somaliensis** Browicz in Arbor. Kórnickie 11: 53 (1966).
Raydah Escarpment, Abha, 2,850 m; Jabal Fayfa, Jizan, 1,180 m.
Type of distribution: SM.

Plantaginaceae
Plantago ovata Forssk. is reported from Abha, 2,200 m by Hosni and Hegazy (1996).

Rubiaceae
Galium aparinoides Forssk., Fl. Aegypt.-Arab.: 30 (1775).
Al-Sudah, Abha, 2,700–2,730 m.
Type of distribution: SM.

***Galium kahelianum** Defl., Voy. Yemen: 145 (1889).
Galium yemense auct. non Kotschy.
Raydah, Abha, 2,380–2,440 m.
Type of distribution: SM.

***Pavetta longiflora** Vahl, Symb. Bot. 3: 12 (1794).
Raydah, 2,090 m; Raydah Village, Abha, 1,500–1,850 m.
Type of distribution: Uncertain.

Pavetta pammalaka Bremek. in Kew Bull. 1948: 350 (1949).
Jabal Fayha, Jizan, 1,200 m.
Type of distribution: Uncertain.

***Pentas lanceolata** (Forssk.) Defl., Voy. Yemen: 142 (1889).
Raydah Village, Abha, 1,500–1,850 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: TA.

***Psydrax schimperiana** (A.Rich.) Bridson in Kew Bull. 40: 714 (1985).
Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: SM.

Tarenna graveolens (S. Moore) Bremek. in Repert. Spec. Nov. Regni Veg. 37: 193 (1934).
subsp. **arabica** (Cuf.) Bridson in Kew Bull. 34: 395 (1979).
Jabal Fayha, Jizan, 1,180 m.
Type of distribution: SM.

***Valantia hispida** L., Syst. Nat. ed 10., 2: 1307 (1759).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: M, IT, SM.

Tubiflorae
Convolvulaceae
***Convolvulus siculus** L., Sp. Pl.: 156 (1753).
subsp. **agrestis** (Hochst. ex Schweinf.) Verdc. in Kew Bull. 1957: 344 (1957). Demissew in Kew Bull. 54: 73 (1989).
Evolvulus agrestis Hochst. ex Schweinf., Beitr. Fl. Aethiop.: 92 (1867).
Raydah, 2,380–2,440 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.
Type of distribution: M.

***Dichondra repens** J.R. et G. Forst., Char. Gen.: 40, t. 20 (1776).
Raydah Nature Reserve, Abha, 2,500–2,590 m.
Type of distribution: W.

***Ipomoea obscura** (L.) Ker-Gawl. in Bot. Reg. 3: t. 239 (1817).
Raydah, Abha, 1,800 m.
Type of distribution: W.

Boraginaceae
Hosni and Hegazy (1996) recorded *Brandella erythraea* (Brand) A. Miller from Al Sodah road, Abha, and

Cynoglossum bottae Defl. from Abha

Alkanna orientalis (L.) Boiss., Diagn. Pl. Orient., ser. 1, 4: 46 (1844). Hosni and Hegazy in Candollea 51: 175 (1996).
Al-Sudah, Abha, 2,700–2,730 m; between Namas and Tanumah, Asir, 2,550 m; Sudah, Abha, 2,680–2,720 m.
Type of distribution: IT, M.

Anchusa affinis R. Br. in S, Voy. Abyss., Append.: 511 (1814).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: SM.

***Cordia monoica** Roxb., Pl. Coromandel 1: 43, t. 58 (1796)
Raydah Village, Abha, 1,700–1,850 m.
Type of distribution: W.

***Cordia nevillii** Alston in Trimen, Handb. Fl. Ceylon 4, Suppl.: 199 (1931)
Raydah Village, Abha, 1,500–1,730 m; Jabal Fayfa, Jizan, 1,180 m.
Type of distribution: W.

***Paracynoglossum lanceolatum** (Forssk.) R.Mill. in R.Mill. and A.G. Miller in Notes Roy. Bot. Gard. Edinburgh 41: 474 (1984).
Cynoglossum lanceolatum Forssk., Fl. Aegypt.-Arab.: 41 (1775).
Al-Sudah, Abha, 2,700–2,730 m; Raydah, 2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,700 m.
Type of distribution: W.

Echium sp.
Waji Deli, border of Asir and Jizan, 1,380−1,690 m.
Hosni and Hegazy (1996) recorded *Echium rauwolfii* Del. from Abha.

***Ehretia abyssinica** R. Br. in S, Voy. Abyss. Append.: 64 (1814).
Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m; Jabal Fayfa, Jizan, 1,200–1,820 m.
Type of distribution: SM.

Heliotropium aegyptiacum Lehm. in Ind. Semin. Hort. Hamb. 1820: 8 (1820). Hosni and Hegazy in Candollea 51: 175 (1996).
Al-Abard, Abha, 2,380 m; Sudah, Abha, 2,680–2,720 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.
Type of distribution: Uncertain.

***Heliotropium arbainense** Fresen. in Mus. Senckenberg. 1: 168 (1833). Hosni and Hegazy in Candollea 51: 175 (1996).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: SS.

***Heliotropium longiflorum** (A. DC.) Hochst. & Steud. ex DC., Prodr. 9: 555 (1845). Hosni and Hegazy in Candollea 51: 176 (1996).
Raydah, 1,800 m; Raydah Village, Abha, 1,300–1,730 m.
Type of distribution:

***Heliotropium** cf. **longiflorum** (A.DC.) Hochst. & Steud. ex DC., Prodr. 9: 555 (1845).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution:

Heliotropium zeylanicum (Burm. f.) Lam., Ill. Gen. 2: 293 (1793).
Jabal Fayha, Jizan, 1,200 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.
Type of distribution:

***Trichodesma trichodemoides** (Bunge) Gürke in Engler and Prantl, Nat. Pflanzenfam. IV, 3a: 99 (1893).
Raydah Village, Abha, 1,640 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: SM.

Verbenaceae
Chascanum marrubifolium Fenzl ex Walp. in Repert. Spec. Nov. Regni Veg. 4: 38 (1845).
Waji Deli, between Abha and Al-Darb, Jizan, 420–1,240 m.
Type of distribution: SM.

Lantana camara L., Sp. Pl.: 627 (1753).
Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: W.

***Lantana petitiana** A. Rich., Tent. Fl. Abyss. 2: 169 (1851).
Al-Mahallah, Abha, 2,350 m; Raydah Village, Abha, 1,500–1,550 m.
Type of distribution: SM.

***Lantana viburnoides** (Forssk.) Vahl, Symb. Bot. 1: 45 (1790).
Raydah, 2,090 m; Raydah Nature Reserve, Abha, 2,100–2,300 m.
Type of distribution: TA.

Lantana sp.
Jabal Fayha, Jizan, 1,200 m.

Premna resinosa (Hochst.) Schauer in DC., Prodr. 11: 637 (1847).
Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.
Type of distribution: SM.

Verbena officinalis L., Sp. Pl.: 21 (1753).
Al-Sudah, Abha, 2,700–2,730 m.
Type of distribution: W (?CN).

Lamiaceae (Labiatae).
Ajuga bracteosa Benth. in Wall., Pl. Asiat. Rar. 1: 59 (1830).
Sughah, Abha, 2,780 m.
Type of distribution: SS, SM.

Ballota cf. **saxatilis** Sieb. ex C. Presl in J. and C. Presl, Del. Prag.: 81 (1822).
Khamis Mushayt, Abha, 2,160 m.
Type of distribution: M.

Lavandula dentata L., Sp. Pl.: 572 (1753). Hosni and Hegazy in Candollea 51: 184 (1996).
Al-Sudah, Abha, 2,700–2,730 m.
Between Namas and Tanumah, Asir, 2,550 m; Sudah, Abha, 2,680–2,720 m; Tamniyah, Asir, 2,360 m.
Type of distribution: SM.

***Lavandula pubescens** Decne. in Ann. Sci. Nat., Bot., sér. 2, 2: 246 (1834). Hosni and Hegazy in Candollea 51: 184 (1996).
Raydah Village, Abha, 1,500–1,730 m; Al-Abard, Abha, 2,380 m; Al-Mahallah, Abha, 2,350 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,560–1,700 m; Tamniyah, Asir, 2,360 m.
Type of distribution: SM.
Hosni and Hegazy (1996) also reported *Lavandula citriodora* A.G.Miller from Abha, 2,000 m.

Marrubium vulgare L., Sp. Pl.: 583 (1753). Hosni and Hegazy in Candollea 51: 184 (1996).
Al-Sudah, Abha, 2,700–2,730 m; Kamer, Asir, 2,720 m; Sudah, Abha, 2,760–2,980 m.
Type of distribution: IT.

Mentha longifolia L., Amoen. Acad. 4: 485 (1759).
subsp. **schimperi** (Briq.) Briq.
Al-Sudah, Abha, 2,700–2,730 m; between Namas and Tanumah, Asir, 2,550 m; Tanumah, Asir, 2,420 m.
Type of distribution: W.

Meriandra bengalensis (Köning ex Rob.) Benth. in Bot. Reg.: t. 1282 (1829).
Kamer, Asir, 2,720 m; Tanumah, Asir, 2,330 m.
Type of distribution: SM.

Micromeria biflora (Ham.) Benth., Labiat. Gen. Spec.: 378 (1834). Hosni and Hegazy in Candollea 51: 184 (1996).
subsp. **arabica** K. Walth.
Al-Sudah, Abha, 2,800 m.
Type of distribution: TA.

***Micromeria imbricata** (Forssk.) C. Chr. in Dansk Bot. Ark. 4: 21 (1922).
Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,780 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: SM.

Micromeria sp.
Waji Deli, border of Asir and Jizan, 1,570–1,690 m; Jabal Fayfa, Jizan, 1,130 m.

***Nepeta deflersiana** Schweinf. ex I.C.Hedge in Notes Roy. Bot. Gard. Edinburgh 40: 65 (1982). Hosni and Hegazy in Candollea 51: 184 (1996).
Al-Sudah, Abha, 2,730–2,800 m; between Namas and Tanumah, Asir, 2,550 m; Raydah Village, Abha, 1,760–1,820 m; Sudah, Abha, 2,680–2,720 m.
Type of distribution: SM.

Orthosiphon pallidus Royle ex Benth., Labiat. Gen. Spec.: 708 (1834). Hosni and Hegazy in Candollea 51: 185 (1996).
Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: SM.

***Orthosiphon thymiforus** (Roth) Sleesen in Reinwardtia 5: 42 (1959).
Raydah Village, Abha, 1,300–1,420 m; Jabal Fayfa, Jizan, 1,130 m.
Type of distribution: SM.

***Otostegia fruticosa** (Forssk.) Schweinf. ex Penz. in Atti Congr. Bot. Genova: 356 (1893).
subsp. **schimperi** (Benth.) Sebald in Stuttgarter Beitr. Naturk., A, No. 263: 66 (1973). Hosni and Hegazy in Candollea 51: 185 (1996).
Al-Abard, Abha, 2,380 m; Al-Mahallah, Abha, 2,350 m; between Namas and Tanumah, Asir, 2,550 m; Raydah, 2,440–2,500 m; Raydah Conservation Area, Abha, 2,500–2,590 m; Sudah, Abha, 2,700 m; Jabal Fayha, Jizan, 1,180 m.
Type of distribution: SM.

*__Plectranthus asirensis__ J.R.I. Wood in Kew Bull. 37: 601 (1983).
Raydah Village, Abha, 1,640 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM.

*__Plectranthus comosus__ Sims in Bot. Mag. 49: t. 2318 (1822).
Raydah, 1,750 m; Raydah Village, Abha, 1,500–1,730 m; Sudah, Abha, 2,680–2,720 m.
Type of distribution: TA.

*__Plectranthus cylindraceus__ Hochst. ex Benth. in DC., Prodr. 12: 60 (1848).
Raydah Village, Abha, 1,500–1,550 m.
Type of distribution: TA.

__Plectranthus__ sp.
Jabal Fayfa, Jizan, 1,180 m.

__Salvia aegyptiaca__ L., Sp. Pl.: 23 (1753).
Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: IT.

__Salvia__ cf. __merjamie__ Forssk., Fl. Aegypt.-Arab.: 10 (1775).
Sudah, Abha, 2,850 m.
Hosni and Hegazy (1996) reported *Salvia lanigera* Poir. from El-Sodah, 2,300 m and also *S. verbenaca* L. from Abha, 2,200 m.

*__Scutellaria rubicunda__ Hornem., Hort. Hafn. 2: 968 (1815).
subsp. __subvelutina__ (Rech.) J.R.Edm. in Notes Roy. Bot. Gard. Edinburgh 38: 53 (1980).
Raydah, 2,440–2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,720 m.
Type of distribution: M.

*__Teucrium yemense__ Defl., Voy. Yemen: 190 (1889). Hosni and Hegazy in Candollea 51: 185 (1996).
Raydah Village, Abha, 1,560–1,700 m; Tamniyah, Asir, 2,360 m.
Type of distribution: SS.

Solanaceae
*__Capsicum annuum__ L.
var. __acuminatum__ Fingerh.
Raydah Village, Abha, 1,500 m.
Type of distribution: CN.

__Datura innoxia__ Mill., Gard. Dict., ed. 8: No. 5 (1768). Hosni and Hegazy in Candollea 51: 193 (1996).

Raydah Village, Abha, 1,300–1,420 m. Waji Deli, between Abha and Al-Darb, Jizan, 1,150–1,420 m.
Type of distribution: SN.

***Datura stramonium** L., Sp. Pl.: 179 (1753). Hosni and Hegazy in Candollea 51: 193 (1996).
Al-Sudah, Abha, 2,800 m; Raydah Village, Abha, 1,300–1,420 m; Tanumah, Asir, 2,280−2,420 m.
Type of distribution: W.

Lycium shawii Roem. and Schult., Syst. Veg. 4: 693 (1819). Hosni and Hegazy in Candollea 51: 193 (1996).
Al-Abard, Abha, 2,380 m; Khamis Mushayt, Abha, 2,160 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Type of distribution: SS.

***Solanum incanum** L., Sp. Pl.: 188 (1753). Hosni and Hegazy in Candollea 51: 193 (1996).
Al-Mahallah, Abha, 2,350 m; Raydah, 2,300–2,500 m; Raydah Nature Reserve, 2100–2300 m; Raydah Village, Abha, 1,300–1,420 m; Sudah, Abha, 2,700 m.
Type of distribution: W.

***Solanum schimperianum** Hochst. ex A. Rich, Tent. Fl. Abyss. 2: 98 (1851). Hosni and Hegazy in Candollea 51: 193 (1996).
Al-Sudah, Abha, 2,700–2,730 m; Ghara, Abha, 2,340 m; between Namas and Tanumah, Asir, 2,550 m; Raydah, 1,930–2,590 m; Raydah Escarpment, 2,200 m; Raydah Village, Abha, 1,720–1,850 m; Sudah, Abha, 2,680–2,720 m; Tamniyah, Asir, 2,360–2,550 m; Tanumah, Asir, 2,330 m; Jabal Ghahar, near Sabya City, Jizan.
Type of distribution: SM.

Solanum sepicula Dunal in DC., Prodr. 13(1): 283 (1852). Hosni and Hegazy in Candollea 51: 193 (1996).
Solanum glabratum Dunal var. *sepicula* (Dunal) *J*.R.I.Wood
Khamis Mushayt, Abha, 2,164 m.
Type of distribution: SM.

Solanum surratense Burm. f., Fl. Indica: 57 (1768).
Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: SM.

***Solanum villosum** (L.) Mill., Gard. Dict., ed. 8: No. 8 (1768).
subsp. **puniceum** (Kirsch.) Edmonds
Raydah Nature Reserve, Abha, 2,500–2,590 m; Tanumah, Asir, 2,330 m.
Type of distribution: W.

***Solanum** cf. **anguivi**
Raydah, 2,300–2,500 m; Raydah Conservation Area, Abha, Asir, 2,500–2,590 m.

***Solanum** sp.
Raydah Conservation Area, 2,100–2,590 m; Raydah Escarpment, Abha, 2,400 m.

***Withania somnifera** (L.) Dunal in DC., Prodr. 13 (1): 453 (1852). Hosni and Hegazy in Candollea 51: 193 (1996).
Al-Sudah, Abha, 2,700–2,730 m; Khamis Mushayt, Abha, 2,164 m; between Namas and Tanumah, Asir, 2,550 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,680–2,720 m; Tanumah, Asir, 2,420 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,150 m.
Type of distribution: W.

Buddlejaceae
***Buddleja polystachya** Fresen. in Flora 21: 605 (1838).
Raydah Village, Abha, 1,720–1,850 m.
Type of distribution: TA.

***Nuxia congesta** R. Br. [in S, Voy. Abyss. Append.: 62 (1814), nom. nud.] ex Fresen. in Flora 21: 606 (1838).
Raydah, 2,500 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Village, Abha, 1,720–1,850 m; Tamniyah, Asir, 2,440–2,550 m; Tanumah, Asir, 2,330 m.
Type of distribution: TA.
Difference from *N. oppositifolia* (Hoshst.) Benth. & DC., Prodr. 10: 435 (1846) is unclear.

Scrophulariaceae
Richards (1994) reported *Craterostigma pumilum* Hochst. from the Asir Mountains.

Anarrhinum forsskalii (J.F. Gmel.) Cuf. in Bull. Jard. Bot. Brux. Suppl. 33: 891 (1963).
Al-Sudah, Abha, 2,700–2,730 m.
Type of distribution: IT.

Camphylanthus pungens Sw. in Mitt. Inst. Allgem. Bot. Hamburg 10: 245 (1939).
Between Abha and Khamis Mushayt, Abha, 2,200 m.
Type of distribution: SS, SM.

Kichxia pseudoscoparia V. W. Smith and D. A. Sutton in D. A. Sutton, Rebis tribe Antirrhineae: 231 (1988).
Between Abha and Khamis Mushayt, Abha, 2,200 m; Al-Mahallah, Abha, 2,350 m.
Type of distribution: SM.

***Kickxia** sp.
Raydah, Abha, 1,720–2,440 m.

Lindenbergia sp.
Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.

***Verbascum melhanense** (Murb.) Hub.-Mor. in Bauhinia 5: 14 (1973).

Raydah Escarpment, Abha, 2,100–2,400 m.

Type of distribution: SM.

***Verbascum** sp.

Al-Sudah, Abha, 2,800 m; between Namas and Tanumah, Asir, 2,360 m; Raydah, 2,380–2,440 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,500–1,550 m.

Hosni and Hegazy (1996) reprted *Verbascum nubicum* Murb. from Abha, 2,200 m, and *Verbascum yemense* Defl. from Abha–El Sodah road, 2,300 m.

***Veronica** sp.

Raydah, 2,500 m; Raydah Nature Reserve, Abha, 2,100–2,300 m; Sudah, Abha, 2,700 m.

Acanthaceae

***Anisotes trisulcus** (Forssk.) Ness in DC., Prodr. 11: 424 (1847).

Raydah Village, Abha, 1,560–1,700 m; Waji Deli, between Abha and Al-Darb, Jizan, 700–1,380 m.

Type of distribution: SM.

***Barleria bispinosa** (Forssk.) Vahl, Symb. Bot. 1: 46 (1790).

Raydah Village, Abha, 1,500–1,850 m.

Type of distribution: SS.

***Blepharis ciliaris** (L.) B.L. Burtt in Notes Roy. Bot. Gard. Edinburgh 22: 94 (1956). Hosni and Hegazy in Candollea 51: 173 (1996).

Raydah Village, Abha, 1,500–1,730 m; Jabal Fayfa, Jizan, 1,370 m;Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Type of distribution: SM.

***Blepharis maderaspatensis** (L.) Heyne ex Roth, Nov. Pl. Sp. Ind. Orient.: 320 (1821).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: SM.

***Crossandra johannianae** Fiori in Bull. Soc. Bot. Ital. 1911: 61 (1911).

Crossandra wissmannii Sw. in Mitt. Inst. Allgem. Bot. Hamburg 8: 420 (1931).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: Endemic.

***Ecbolium gymnostachyum** (Nees) Milne-Redh. ex Gillett in Kew Bull. 1941: 175 (1941).

Raydah Village, Abha, 1,500–1,550 m.

Type of distribution: SM.

***Hypoestes forskalii** (Vahl) R.Br. [in Salt, Voy. Abyss., App.: 63 (1814), nom. nud.] ex Roem. & Schult., Syst. Veg. 1: 140 (1817).
Sudah, Abha, 2,680–2,720 m; Raydah, 1,930 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,500–1,550 m; Tamniyah, Asir, 2,360 m; Tanumah, Asir, 2,330 m.
Type of distribution: TA.

***Justicia flava** (Vahl) Vahl, Symb. Bot. 2: 15 (1791).
Raydah Village, Abha, 1,300–1,730 m.
Type of distribution: TA .

***Megalochlamys violacea** (Vahl) Vollesen in Kew Bull. 44: 608 (1989).
Ecbolium violaveum (Vahl) Hillc. & J.R.I. Wood in Kew Bull. 38: 446 (1983).
Raydah Village, Abha, 1,500–1,550 m.
Type of distribution: SM.

***Monechma dabile** (Forssk.) Nees in DC., Prodr. 11: 411 (1847).
Raydah, 2,380–2,440 m; Raydah Village, Abha, 1,500–1,850 m.
Type of distribution: W.

***Peristrophe paniculata** (Forssk.) Bru mmitt in Kew Bull. 30: 451 (1983).
Raydah, 2,380–2,440 m; Raydah Nature Reserve, Abha, 2,100–2,300 m.
Type of distribution: W.

***Peristrophe** sp.
Raydah, Abha, 2,500 m.

***Ruellia grandiflora** (Forssk.) Pers., Syn. Pl. 2: 175 (1806); Blatter, Fl. Arab.: 353 (1923).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: SM.

***Ruellia patula** Jacq., Misc. Austr. Bot. 2: 358 (1781). Hosni and Hegazy in Candollea 51: 173 (1996).
Raydah, 1,800 m; Raydah Village, Abha, 1,300–1,420 m; Wadi Deli, between Abha and Al-Darb, Jizan, 940–1,000 m.
Type of distribution: TA.

Orobanchaceae
Orobanche ramosa L., Sp. Pl.: 633 (1753). Hosni and Hegazy in Candollea 51: 190 (1996).
Sudah, Abha, 2,760 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.
Type of distribution: W.

Dipsacales

Caprifoliaceae

***Lonicera etrusca** Santi, Viagg. Mont. 1: 113, t. 1(1795).

Al-Sudah, Abha, 2,800 m; Billasmar, Asir, 2,800 m; between Namas and Tanumah, Asir, 2,360 m; Raydah, Abha, 2,500 m; Sudah, Abha, 2,780 m.

Type of distribution: M.

Dipsacaceae

Hosni and Hegazy (1996) reported *Petrocephalus pulverulentus* Boiss. and Bal. from Al Sodha, 2,300 m.

***Scabiosa columbaria** L., Sp. Pl.: 143 (1753).

Raydah, Abha, 2,500 m.

Type of distribution: W.

Campanulales

Campanulaceae

Campanula edulis Forssk., Fl. Aegypt.-Arab.: 44 (1775).

Campanula rigidipila Steud. & Hochst. ex A.Rich., Tent. Fl. Abyss. 2: 3 (1850).

Jabal Fayfa, Jizan, 1,820 m.

Type of distribution: SM.

Asteraceae (Compositae).

Achillea arabica Kotschy. Hosni and Hegazy in Candollea 51: 178 (1996).

Sudah, Abha, 2,700 m.

Type of distribution: SM.

Anthemis yemenensis Podlech in Mitt. Bot. Munchen 18: 427 (1982).

Sudah, Abha, 2,760 m.

Type of distribution: SM.

Hosni and Hegazy (1996) reported *Anthemis tigreensis J.* Gay ex A.Rich. from Abha–Al Sodah road, 2,300 m.

***Bidens biternata** (Lour.) Merr. & Sherff in Sherff in Bot. Gaz. 88: 293 (1929).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: W.

Hosni and Hegazy (1996) reported *Bidens bipinnata* L. from Aqbet Dalaa, 1,000–2,000 m.

Bidens sp.

Jabal Fayfa, Jizan, 1,820 m.

Calendula sp.

Sudah, Abha, 2,760 m.

Hosni and Hegazy (1996) reported *Calendula arvensis* L. from Abha, 2,200 m.

Centaurea eryngioides Lam., Encycl. 1: 675 (1785).

Waji Deli, border of Asir and Jizan, 1,570–1,690 m.

Type of distribution: IT.

***Centaurothamnus maximus** (Forssk.) Wagenitz & Dittr. in Candollea 37: 111 (1982).

Centaurea maxima Forssk., Fl. Aegypt.-Arab.: 152 (1775).

Raydah Escarpment, Abha, 2,800 m.

Type of distribution: SM.

Cichorium intybus L., Sp. Pl.: 813 (1753).

Tanumah, Asir, 2,330 m.

Type of distribution: W.

Hosni and Hegazy (1996) reported Cichorium bottae Defl. from Al Sodah, 2,300 m.

***Cineraria abyssinica** Sch. Bip. ex A. Rich., Tent. Fl. Abyss. 1: 433 (1847).

Al-Sudah, Abha, 2,700–2,730 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,700 m.

Type of distribution: SM.

***Cirisium vulgare** (Savi) Tenore, Syll. Fl. Nap. Append. 5: 209 (1835-36).

Raydah, Abha, 2,500 m; Sudah, Abha, 2,780 m.

Type of distribution: W.

***Conyza hochstetteri** Sch. Bip. ex A.Rich., Tent. Fl. Abyss. 1: 387 (1847).

Al-Sudah, Abha, 2,700–2,730 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.

Type of distribution: TA.

Conyza squamata Spreng., Syst. Veg. 3: 515 (1826).

Aster squamantus (Spreng.) Hieron. ex Sod. in Engl., Bot. Jahrb. 29: 19 (1900).

Conyzanthus squamatus (Spreng.) Tamamasch. in Fl. URSS 25: 186 (1959).

Khamis Mushayt, Abha, 2,160 m.

Type of distribution: Native of North America, and naturalized.

Conyza cf. **stricta** Willd., Sp. Pl. 3: 1922 (1803).

Al-Sudah, Abha, 2,800 m.

Conyza sp.

Al-Sudah, Abha, 2,700–2,730 m; between Namas and Tanumah, Asir, 2,360 m; Jabal Fayfa, Jizan, 1,820 m.
Hosni and Hegazy (1996) reported *Conyza incana* Willd. from Abha, 2,200 m.

Crepis sp.
Al-Sudah, Abha, 2,850 m; Jabal Fayfa, Jizan, 1,820 m.

***Dichrocephala chrysanthemifolia** (Blume) DC. in Guill., Archv. Bot. 2: 518 (1833).
Between Namas and Tanumah, Asir, 2,550 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 3,050 m; Jabal Fayfa, Jizan, 1,180 m.
Type of distribution: W.

***Echinops** sp. 1.
Raydah Escarpment, Abha, 2,850 m.

Echinops sp. 2.
Al-Sudah, Abha, 2,960 m.

Echinops sp. 3.
Al-Sudah, Abha, 2,700–2,730 m.

***Echinops** sp. 4.
Between Namas and Tanumah, Asir, 2,360 m; Raydah Village, Abha, 1,700 m; Sudah, Abha, 2,680–3,000 m; Tanumah, Asir, 2,420 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Hosni and Hegazy (1996) reported *Echinops spinosissimus* Turra from Abha, 2,200 m, and *E. spinosus* L. from Abha–Al Sodah road, 2,300 m.

***Euryops arabicus** Steud. ex Jaub. & Spach, Ill. Pl. Orient. 4: 88, t. 355 (1852). Hosni and Hegazy in Candollea 51: 179 (1996).
Al-Sudah, Abha, 2,700–2,980 m; Billasmar, Asir, 2,800 m; Kamer, Asir, 2,720 m; between Namas and Tanumah, Asir, 2,550 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Tamniyah, Asir, 2,360–2,550 m; Tanumah, Asir, 2,280 m.
Type of distribution: SM.

Felicia abyssinica Sch. Bip. ex A. Rich., Tent. Fl. Abyss. 1: 383 (1847). Hosni and Hegazy in Candollea 51: 179 (1996).
Al-Sudah, Abha, 2,800 m; Tanumah, Asir, 2,330 m.
Type of distribution: SM.

Flaveria trinervia (Spreng.) Mohr. in U.S. Dept. Agr., Contr. Nat. Herb. 6: 810 (1901).
Al-Abard, Abha, 2,380 m; Khamis Mushayt, Abha, 2,160 m.
Type of distribution: W.

***Helichrysum foetidum** (L.) Moench., Meth.: 575 (1794).

var. **microcephalum** A. Rich., Tent. Fl. Abyss. 1: 426 (1848).

Al-Sudah, Abha, 2,730–2,800 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,700–2,780 m.

Type of distribution: TA.

***Helichrysum forsskalii** (J.F.Gmel.) Hilliard and Burtt in Notes Roy. Bot. Gard. Edinburgh 38: 146 (1980).

Between Namas and Tanumah, Asir, 2,550 m; Raydah, 2,500 m; Raydah Escarpment, Abha, 2,850 m; Sudah, Abha, 2,700 m.

Type of distribution: TA.

***Helichrysum** sp.

Raydah Conservation Area, Abha, 2,500–2,590 m.

Kleinia odora (Forssk.) DC., Prodr. 6: 339 (1838). Halliday in Kew Bull. 39: 825 (1984).

Cacalia odora Forssk., Fl. Aeg.-Arb.: 146 (1775).

Between Abha and Khamis Mushayt, Abha, 2,200 m; Khamis Mushayt, Abha, 2,160 m.

Type of distribution: SM.

Lactuca serriola L., Cent. Pl. 2: 29, no. 189 (1756). Hosni and Hegazy in Candollea 51: 179 (1996).

Al-Sudah, Abha, 2,700–2,730 m.

Type of distribution: W.

***Osteospermum vaillantii** (Decne.) Norl., Stud. Calend. 1: 305 (1943). Hosni and Hegazy in Candollea 51: 179 (1996).

Tripteris vaillantii Decne. in Ann. Sci. Nat., Ser. 2, 2: 260 (1834).

Al-Sudah, Abha, 2,700–2,730 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Tanumah, Asir, 2,330 m.

Type of distribution: SS.

***Pegolettia senegalensis** Cass., Dict. Sci. Nat. 38: 232 (1825).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: TA.

Phagnalon stenolepis Chiov. in Ann. Bot. Roma 9: 71 (1911).

Kamer, Asir, 2,720 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

Type of distribution: SM.

Phagnalon sp.

Al-Sudah, Abha, 2,700–2,730 m.

Picris sp.

Al-Sudah, Abha, 2,700–2,730 m; Sudah, Abha, 2,980 m.

***Pluchea dioscoridis** (L.) DC., Prodr. 5: 450 (1836).

Raydah Village, Abha, 1,500–1,730 m; Jabal Fayfa, Jizan, 1,130 m.

Type of distribution: SS, TA.

***Pluchea ovalis** (Pers.) DC., Prodr. 5: 450 (1836).

Al-Abard, Abha, 2,380 m; Raydah Village, Abha, 1,500–1,730 m; Tanumah, Asir, 2,280–2,420 m.

Type of distribution: SM.

***Psiadia punctulata** (DC.) Vatke in Oestr. Bot. Zeit. 27: 196 (1852).

Al-Mahallah, Abha, 2,350 m; between Namas and Tanumah, Asir, 2,550 m; Raydah, 1,930–2,500 m; Raydah Conservation Area, Abha, 2,500–2,590 m; Sudah, Abha, 2,680–2,720 m.

Type of distribution: TA.

Hosni and Hegazy (1996) reported *Psiadia arabica* Jaub. and Spach from Abha–El Sodah road, 2,300 m.

Pulicaria arabica (L.) Cass., Dict. Sci. Nat. 44: 94 (1826).

Al-Sudah, Abha, 2,960 m.

Type of distribution: IT, M.

***Pulicaria undulata** (L.) C.A.Mey.,Verz. Pfl. Casp. Meer: 79 (1831).

Pulicaria crispa (Forssk) Benth. ex Oliv. in Grant in Trans. Linn. Soc. London 29: 96 (1873).

Aster crispus Forssk., Fl. Aegypt.-Arab.: 150 (1775).

Al-Sudah, Abha, 2,960 m; Billasmar, Asir, 2,800 m; Raydah Village, Abha, 1,760–1,820 m; Waji Deli, border of Asir and Jizan, 1,570–1,690 m.

Type of distribution: SM, SS, IT.

Pulicaria glutinosa (Boiss.) Jaub. & Spach, Ill. Pl. Orient. 4: 77, t. 348 (1852).

Khamis Mushayt, Abha, 2,160 m.

Type of distribution: SM.

Pulicaria jaubertii Gamal-Eldin in Pulicaria: 143 (1981).

Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

Type of distribution: SS, SM.

***Pulicaria petiolaris** Jaub. & Spach, Ill. Pl. Orient. 4: 69, t. 344 (1852).

Raydah Village, Abha, 1500–1,730 m.

Type of distribution: SM.

***Pulicaria schimperi** DC., Prodr. 7: 285 (1838). Hosni and Hegazy in Candollea 51: 180 (1996).
Al-Abard, Abha, 2,380 m; Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,200–1,380 m.
Type of distribution: SS.

Pulicaria vulgaris Gaertn., Fruct. Sem. Pl. 2: 461, t. 173 (1791).
Al-Sudah, Abha, 2,960 m; Sudah, Abha, 2,680–2,720 m; Tanumah, Asir, 2,420 m.
Type of distribution: W.
Hosni and Hegazy (1996) reported *Pulicaria undulata* (L.) C.A. Mey. from Abha–El Soda road, 2,300 m.

Scorzonera musilii Velen. in Sitzungsber. Königl. Böhm. Ges. Wiss. Prag. Math.-Naturwiss. Cl. 11: 8 (1912).
Between Abha and Khamis Mushayt, Abha, 2,200 m.
Type of distribution: SS.

Scorzonera sp.
Waji Deli, border of Asir and Jizan, 1,570–1,690 m.
Hosni and Hegazy (1996) recorded *Scorzonera tortuosissima* Boiss. from Abha, 2,200 m.

***Senecio asirensis** L. Boulos & J.R.I.Wood in Kew Bull. 38: 491 (1983).
Between Namas and Tanumah, Asir, 2,360 m; Raydah, 2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, Abha, 2,200 m; Sudah, Abha, 2,620–2,980 m.
Type of distribution: SS.

***Senecio hadiensis** Forssk., Fl. Aegypt.-Arab.: 149 (1775).
Raydah, 2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, 2,400 m; Raydah Village, Abha, 1,640–2,500 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM.

***Senecio lyratus** Forssk., Fl. Aegypt.-Arab.: 148 (1775).
Cineraria lyratipartita (Sch. Bip. ex A.Rich.) Cuf. in Bull. Jard. Bot. Nat. Belg. 37: suppl. 1152 (1967).
Raydah, 2,300–2,500 m; Raydah Escarpment, 2,400 m; Raydah Village, Abha, 1,500–1,550 m.
Type of distribution: SM.

***Senecio schimperi** Sch. Bip. ex A. Rich., Tent. Fl. Abyss. 1: 435 (1847).
Al-Sudah, Abha, 2,700–2,730 m; Raydah, Abha, 2,380–2,440 m; Tanumah, Asir, 2,280 m.
Type of distribution: SM.
Hosni and Hegazy (1996) reported Senecio odorus Sch.-Bip.from Abha, 2,200 m.

***Solanecio angulata** (Vahl) C. Jeffrey in Kew Bull. 41: 922 (1986).
Senecio bojeri DC., Prodr. 6: 37 (1838).

Raydah Village, Abha, 1,640 m; Jabal Fayfa, Jizan, 1,820 m.
Type of distribution: SM, TA.

***Tagetes mimuta** L., Sp. Pl.: 887 (1753).
Raydah, 2,500 m; Raydah Village, 1300–1420 m; Sudah, Abha, 2,700 m; Tanumah, Asir, 2,280 m.
Type of distribution: C, N.

***Tarchonanthus camphoratus** L., Sp. Pl.: 842 (1753).
Raydah, 2,090 m; Raydah Escarpment, 2,200 m; Raydah Village, Abha, 1,760–2,000 m; Jabal Ghahar, near Sabya City, Jizan.
Type of distribution: SM.

***Verbesina encelioides** (Cav.) Benth. & Hook. f. ex A. Gray in Brewer, S. Watson and A. Gray, Bot. Calif. 1: 350 (1876). Hosni and Hegazy in Candollea 51: 180 (1996).
Raydah, 1,930 m; Raydah Nature Reserve, 2,100–2,300 m; Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: CN (native of North America, and natauralized in Europe, Afirca to South Asia).

***Vernonia** cf. **leopoldii** (Sch. Bip.) Vatke in Linnaea 39: 478 (1875).
Raydah, 2,380–2,500 m; Raydah Nature Reserve, 2,500–2,590 m; Raydah Village, Abha, 1,760–1,820 m.

Vernonia sp.
Sudah, Abha, 2,700 m.

Xanthium pungens Wallr., Beitr. Bot. 1: 231 (1842). Hosni and Hegazy in Candollea 51: 180 (1996).
Zabinan, Abha, 2,630 m.
Type of distribution: CN.

MONOCOTYLEDONAE

Arecaceae (Palmae).

Phoenix caespitosa Chiov., Fl. Somala 1: 317 (1929).

Between Namas and Tanumah, Asir, 2,360 m.

Type of distribution: SM.

It is still uncertain whether this can be separated from *P. reclinata* Jacq. [Fragm. 1: 27, t.24 (1801)] (as var. *somalensis* Beccari ex Chiov.)

Araceae

***Arisaema flavum** (Forrsk.) Schott., Prodr. Syst. Aroid.: 40 (1860).

Raydah Nature Reserve, 2,500–2,590 m; Raydah Escarpment, Abha, 2,850 m; Sudah, Abha, 2,780 m.

Type of distribution: SM, IT.

Commelinaceae

Aneilema forskalei Kunth, Enum. Pl. 4: 71 (1843).

Jabal Fayha, Jizan, 1,180 m.

Type of distribution: TA.

***Cyanotis nyctitropa** Defl. in Bull. Soc. Bot. France 43: 234 (1894).

Raydah Village, Abha, 1,300–1,850 m.

Type of distribution: SM.

Cyperaceae

***Carex distans** L., Syst. Nat., ed. 10, 2: 1263 (1759).

Raydah Escarpment, Abha, 2,500 m.

Type of distribution: W.

***Carex** sp. 1.

Raydah, 2,380–2,440 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.

***Carex** sp. 2 (probably new species)

Raydah Nature Reserve, Abha, 2,500–2,590 m.

***Cyperus conglomeratus** Rottb., Descr. Pl. Rar. Progra mm.: 16, no. 29 (1772). Hosni and Hegazy in Candollea 51: 196 (1996).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: SS.

***Cyperus michelianus** (L.) Delile, Fl. Aeg. Ill.: 50 (1813).
subsp. **pygmaeus** (Rottb.) Aschers. & Graebn.
Tanumah, Asir, 2,330 m; Raydah Village, Abha, 1,560–1,700 m.
Type of distribution: W.

Cyperus rubicundus Vahl, Enum. Pl. 2: 308 (1805).
Al-Sudah, Abha, 2,700–2,730 m; Sudah, Abha, 2,700 m.
Type of distribution: TA.

Cyperus shimperianus Steud., Syn. Pl. Glumac. 2: 34 (1854).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: TA.

***Cyperus** sp.
Raydah Village, Abha, 1,500–2,500 m.

Eleocharis marginulata Hochst. ex Steud., Syn. Pl. Glumac. 2: 78 (1854).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: Uncertain.

Fuirena pubescens (Lam.) Kunth, Enum. Pl. 2: 182 (1837).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: W.

Scirpus brachyceras Hochst. ex A. Rich., Tent. Fl. Abyss. 2: 496 (1851).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: Uncertain.

Juncaceae
Juncus rigidus Desf., Fl. Atlant. 1: 312 (1798).
Khamis Mushayt, Abha, 2,160 m.
Type of distribution: W.

Liliaceae
Aloe castellorum J.R.I. Wood in Kew Bull. 38: 25 (1983).
Jabal Fayfa, Jizan, 1,750 m.
Type of distribution: SM.

***Aloe fleurentiniorum** Lavr. & Newton in Cactus Succ. *J.* (U.S.A.) 49: 113 (1977).
Raydah Village, Abha, 1,500–1,730 m.

Type of distribution: SM.

***Aloe sabaea** Schweinf. in Bull. Herb. Boissier 2: append. 2: 74 (1894).
Raydah, Abha, 1,840–1,940 m; Raydah Escarpment, 1,900 m; Raydah Village, Abha, 1,900 m.
Type of distribution: SM.

Aloe shadensis Lavr. & Collen. [in Collen., Wildfl. Saudi Arab.: f. 6718, 6741, 9313 (1999), nom. nud.] in Cactus Succ. J. (U.S.A.) 72: 82 (2000).
Suqah, Abha, 2,700 m.
Type of distribution: SM.
This was described recently based on the Collenette collection from Hijaz Province (Collenette 6718, K).

***Aloe** sp.
Raydah Village, Abha, 1,500 m.

***Asparagus africanus** Lam., Encycl. 1: 295 (1783). Hosni and Hegazy in Candollea 51: 202 (1996).
Al-Mahallah, Abha, 2,350 m; Al-Sudah, Abha, 2,700–2,730 m; Billasmar, Asir, 2,800 m; Between Namas and Tanumah, Asir, 2,360 m; Raydah, 2,380–2,440 m; Raydah Village, Abha, 1,500–1,550 m; Sudah, Abha, 2,680–2,720 m; Tanumah, Asir, 2,330 m; Jabal Fayha, Jizan, 1,180 m.
Type of distribution: TA.

***Asphodelus** cf. **aestivus** Brot., Fl. Lusit. 1: 525 (1804).
Al-Sudah, Abha, 2,800 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.
Asphodelus fistulosus var. *tenuifolius* (Cav.) Baker is recorded from Abha, 2,200 m by Hosni and Hegazy (1996).

***Crinum album** (Forssk.) Herb., Amaryllidaceae: 272 (1837).
Raydah Village, Abha, 2,000 m.
Type of distribution: SM.

Scadoxus multiflorus (Martyn) Raf., Fl. Tellur. 4: 19 (1838).
Tamniyah, Asir, 2,440 m.
Type of distribution: TA.

Poaceae (Gramineae).
Hosni and Hegazy (1996) reported the following species: *Bromus diandrus* Roth from Abha, 2,200 m, *Lamarckia aurea* (L.) Moench from Abha, 2,200 m., *Phalaris paradoxa* L. from Abha, 2,200 m and *Tetrapogon villosus* Desf. from Abha, 2,200 m.

***Andropogon distachyos** L., Sp. Pl.: 1046 (1753).
Between Namas and Tanumah, Asir, 2,550 m; Raydah, 2,380–2,440 m; Raydah Nature Reserve, 2,500–2,590 m;

Raydah Escarpment, Abha, 2,800 m; Sudah, Abha, 2,700–2,980 m.
Type of distribution: M, TA.

***Aristida adscensionis** L., Sp. Pl.: 82 (1753).
Raydah, Abha, 2,380–2,440 m; Wadi Deli, between Abha and Al-Darb, Jizan, 1,000−1,380 m.
Type of distribution: W.

***Bothriochloa ischaemum** (L.) Keng in Contr. Biol. Lab. Sci. Soc. China, Bot. Ser. 10: 201 (1936).
Between Abha and Khamis Mushayt, Abha, 2,200 m; Jabal Fayfa, Jizan, 1,180 m; Between Namas and Tanumah, Asir, 2,550 m; Raydah, Abha, 2,300–2,500 m; Sudah, Abha, 2,700 m.
Type of distribution: W.

***Brachiaria leersioides** (Hochst.) Stepf in Prain, Fl. Trop. Afr. 9: 551 (1919).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: TA.

***Brachypodium retusum** (Pers.) P. Beauv., Ess. Agrost.: 101, 155 (1812).
Raydah Nature Reserve, Abha, 2,500–2,590 m.
Type of distribution: M.

***Brachypodium** sp.
Raydah Nature Reserve, Abha, 2,500–2,590 m.

***Cenchrus ciliaris** L., Mant. Pl.: 302 (1761). Hosni and Hegazy in Candollea 51: 197 (1996).
Raydah, Abha, 2,380–2,440 m.
Type of distribution: CN.

Chrysopogon plumulosus Hochst., Jahreshefte Württ. 3: 62 (1847).
Tamniyah, Asir, 2,360 m [000604 III 13].
Type of distribution: SM.

***Digitaria ciliaris** (Retz.) Koeler, Descr. Gram. Gal. Germ.: 27 (1802). Hosni and Hegazy in Candollea 51: 198 (1996).
Raydah Nature Reserve, Abha, 2,500–2,590 m; Waji Deli, between Abha and Al-Darb, Jizan, 1,000–1,380 m.
Type of distribution: W.

Digitaria cf. **nodosa** Parl., Pl. Nov.: 39 (1842).
Waji Deli, between Abha and Al-Darb, Jizan, 1,380 m.

***Digitaria** sp.

Raydah Village, Abha, 1,500–1,730 m; Jabal Fayha, between Ayid and Fayha, Jizan, 1,890 m.

***Eleusine indica** (L.) Gaertn, Fruch. Sem. Pl. 1: 8 (1788).
Raydah Village, Abha, 1,300–1,420 m.
Type of distribution: W.

Eragrostis barrelieri Daveau in Morot, *J.* Bot. (Paris) 8: 289 (1894).
Sudah, Abha, 2,700 m.
Type of distribution: W.

Eragrostis cf. **curvula** (Schrad.) Nees, Fl. Afr. Austr.: 397 (1841).
Sudah, Abha, 2,950 m.

***Eragrostis papposa** (Roem. et Schult.) Steud., Syst. Pl. Glum. 1: 263 (1854).
Raydah, Abha, 1,800–2,500 m; Tanumah, Asir, 2,330 m.
Type of distribution: SS, M.

***Eragrostis** sp.
Raydah, Abha, 2,020 m.

Festuca arundinacea Schreb., Spicil. Fl. Lips.: 57 (1771).
Sudah, Abha, 2,780–2,950 m.
Type of distribution: W.

Gastridium phleoides (Nees & Meyen) C.E. Hubb. in Kew Bull 1954: 375 (1954).
Sudah, Abha, 2,700 m.
Type of distribution: IT.

***Hyparrhenia hirta** (L.) Stapf in Prain, Fl. Trop. Afr. 9: 315 (1918). Hosni and Hegazy in Candollea 51: 199 (1996).
Raydah, 2,300–2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m; Sudah, Abha, 2,980 m; Tanumah, Asir, 2,280– 2,330 m.
Type of distribution: W.

Oryzopsis miliacea (L.) Asch. & Schweinf. in Mém. Inst. Egypt. 2: 169 (1887).
Between Namas and Tanumah, Asir, 2,360 m.
Type of distribution: IT, M.

***Panicum maximum** Jacq., Icon. Pl. Rar. 1: 2, t. 13 (1781).
Raydah Village, Abha, 1,500–1,730 m.
Type of distribution: W.

***Pennisetum nubicum** (Hochst.) K. Schum. ex Engl. in Abh. Preuss. Akad. Wiss.: 58 (1894).

Raydah Village, Abha, 1,720–1,850 m.

Type of distribution: SM.

***Pennisetum setaceum** (Forssk.) Chiov. in Boll. Soc. Bot. Ital. 1923: 113 (1923).

Raydah, Abha, 2,300–2,500 m.

Type of distribution: W.

Pennisetum villosum R. Br. ex Fresen. in Mus. Senckenberg. 2: 134 (1837). Hosni and Hegazy in Candollea 51: 200 (1996).

Al-Sudah, Abha, 2,700–2,730 m; Sudah, Abha, 2,700– 2,780 m.

Type of distribution: SM.

Pennisetum sp.

Khamis Mushayt, Abha, 2,164 m.

Pennisetum setaceum (Forssk,) Chiov. was reported from Abha, 2,200 m by Hosni and Hegazy (1996).

***Poa schimperana** Hochst. ex A. Rich., Tent. Fl. Abyss. 2: 423 (1851).

Raydah Escarpment, Abha, 2,400 m.

Type of distribution: TA.

Poa sp.

Between Namas and Tanumah, Asir, 2,550 m; Raydah Conservation Area, 2,500–2,590 m; Sudah, Abha, 2,760 m.

***Polypogon schimperianus** (Hochst. ex Steud.) Cope in Kew Bull. 50: 116 (1995).

Raydah, 2,500 m; Raydah Nature Reserve, Abha, 2,500–2,590 m.

Type of distribution: SM.

***Stipa parviflora** Desf., Fl. Atlant. 1: 98, t. 29 (1798).

Raydah Escarpment, Abha, 2,400 m.

Type of distribution: IT, M.

***Stipa** sp.

Raydah Nature Reserve, Abha, 2,500–2,590 m.

***Tragus berteronianus** Schult., Syst. Veg., ed. 15, 2: Mant. 205 (1824).

Raydah Village, Abha, 1,300–1,420 m.

Type of distribution: W.

Vulpia muralis (Kunth) Nees in Linnaea 19: 694 (1847).

Tamniyah, Asir, 2,360 m.

Type of distribution: M.

Velloziaceae

Xerophyta arabica (Bak.) N. Menezes in Cienc. Cult. 23, 3: 422 (1971).

Jabal Fayfa, Jizan, 1,130 m.

Type of distribution: SM.