



Studies of *Ephedra* plants in Asia. Part 5¹⁾. The herbivory damage to *Ephedra* plants by livestock

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The aerial part of *Ephedra sinica* Stapf growing in a natural habitat were cut early in the spring for the purpose of examining the effects of herbivory damage by livestock including sheep and goats. The results showed that the plants never generated new stem afterwards in the same year after cutting the aerial parts and did not make cones. In the next season, the plant became small in size and scarcely made cones. Through this study, it was confirmed experimentally that the herbivory damage to plant growth of *E. sinica* by livestock was serious.

Key words herbivory damage, livestock, *Ephedra sinica*, Ma-huang.

Introduction

Plants of *Ephedra* species contain ephedrine group alkaloids, which are a treatment for asthma in Western medicine and are used as an important crude drug, named Ma-huang, in traditional Chinese Medicine. The availability of Ma-huang has reduced rapidly in China recently, and the Chinese government²⁾ banned the export of Ma-huang in 1999 in order to conserve the current resources.

We have been carrying out interdisciplinary studies on *Ephedra* plants, and reported previously that there was a risk of herbivory damage to *Ephedra* plants by livestock such as sheep and goats,³⁾ which could result in a decrease in wild *Ephedra* plants resources. We carried out this study to confirm the degree of actual herbivory damage by livestock to *Ephedra* plants experimentally.

Ephedra plants sprout shoots and bloom early in the spring, and the female cones mature in the middle of July in the province of He-bei, China. We found that few plants except *Ephedra* put up shoots in the natural habitat in the early spring, and livestock ate the young shoots of *Ephedra* before flowering (Fig.1, 2).³⁾ In the Inner Mongolia autonomy district, we interviewed a shepherd who had set up a fence to defend wild *Ephedra* from sheep, and then collected and sold it as a cash crop. This fact suggested that there was considerable herbivory damage to *Ephedra* plants by sheep. In Nepal Himalayas, wild stocks of *Ephedra* were witnessed being eaten by sheep and goats. The sheep and goats seemed to preferentially eating *Ephedra*, which was called by the local name of "Sheep's sweet" in Manan village in Western Nepal. Therefore, we examined the severity of the herbivory damage to *Ephedra* plants by livestock in this study.

Experimental

Experimental field. The natural habitat of *Ephedra sinica* Stapf at the seacoast of Nan-dai-he, Qin-hwang-dao in the

Province of He-bei (Fig.3). This coast is a famous summer resort located east of Beijing, and was judged as an appropriate place for this study because no signs of grazing were found. The coastline upheaves about one and a half meters at the beach, and a sandy flatland of about 50 m wide lies between the coast and a raised road along the beach. Colonies of *Ephedra* were seen here and there, and the nearest colony from the coastline was recognized around ten meters in from the coastline. Besides *Ephedra*, many small plants of *Zizyphus jujuba* Mill. var. *spinosa* (Bunge) Hu, *Calystegia soldanella* (L.) Roem. et Schult., *Cynanchum* sp., *Euphorbia octoradiata* H. Levl. et Vaniot, *Allium bidentatum* Fisch. ex Prokh., and some mono-cotyledonous plants such as of the families Gramineae and Cyperaceae were recognized.

Experimental method and Result

We visited the experimental site on May 7th 2006, in the season when *Ephedra* plants are most likely to be eaten by sheep. At the site, we chose one *Ephedra* colony, which included many female plants of 10-15 cm in height with many green young female buds, cones, at the top of the stems (Fig. 4), and cut most of the shoots in about two square meters with scissors, leaving 2-4 cm from the base (Fig. 5). In this season, the plant of *Zizyphus jujuba* var. *spinosa* had not sprouted yet, while *Euphorbia octoradiata* was in full-bloom.

On visiting the site again after 20 days, many flowering yellow male cones were observed. There was no change in the cut stock, and there was no sign of shooting of new stems or buds.

We revisited the site on August 22 of the same year. Most of the female cones had dropped off from the stock although some shriveled deep red cones remained at the top of the stems. At the experimental site, there was no sign of sprouting of new shoots from the cut stock while the cut short stalks had scarcely changed their shape or green color

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Fig. 1 *Ephedra* plants eaten by sheep, in Inner Mongolia, China (left).



Fig. 4 Before cutting. The female plants attaching cones are 10-15 cm in height.

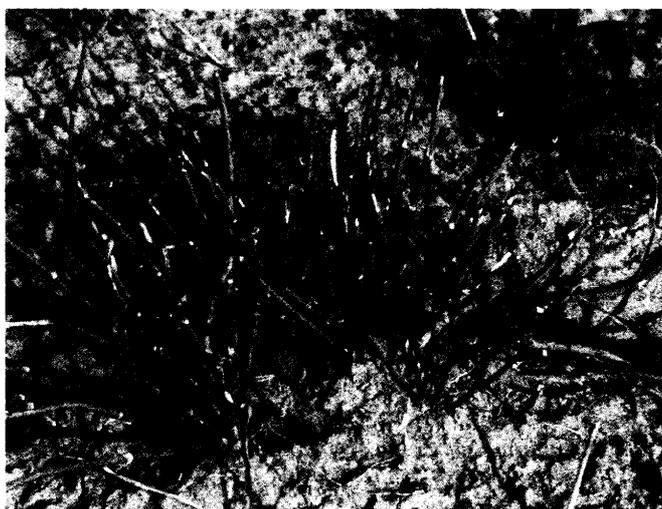


Fig. 2 *Ephedra* plants eaten by sheep, in Inner Mongolia. Remaining stems are 3-7 cm in length.



Fig. 5 After cutting. Remaining stems are 2-4 cm in length. May 7th, 2006.



Fig. 3 *Ephedra* habitat at the seacoast of Nan-dai-he, Hebei, China.



Fig. 6 Growth conditions of *Ephedra* plants one year after cutting, observed on May 30, 2007.

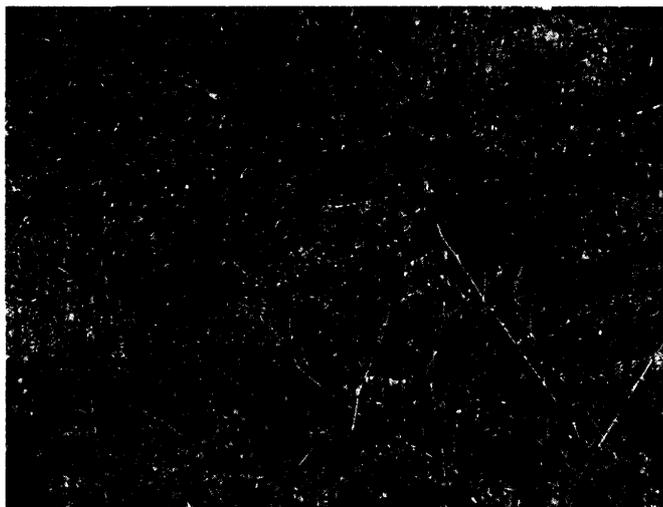


Fig. 7 Growth conditions of *Ephedra* plants in normal colony, on the same day as of Fig. 6.

since the spring. We could find no shoots sprouting from the cut *Ephedra* stocks once the aerial part was cut in the early spring although the stocks did not die.

We visited the site next spring on May 30, 2007. The flowering season of *Euphorbia octoradiata* was over, and *Cynanchum* sp. and *Calystegia soldanella* were in bloom. *Ephedra* was just in bloom, and some bees visited the yellow male flowers. In the experimental field, it was observed that the plants cut in the last spring scarcely put forth cones (Fig. 6). The remaining stalks cut last year were not observed and had withered in the winter as well as stalks of other colonies. Moreover, it was observed that some *Ephedra* plants close to the experimental area also showed poor levels of flowering, compared to those in normal colonies (Fig. 7). In addition, on Aug. 22, 2007, we collected and measured the plants in the experimental area, which were found to be small in size, 60-120 (S.D.= ± 17.05 , n=6.) mm in height (Voucher specimen No. 70822A02), compared to normal plants in the same colony that were 130-230 (S.D.= ± 31.93 , n=7.) mm in height (Voucher specimen No. 70822A01).

Conclusion and Discussions

1. We observed a *Ephedra sinica* habitat for one and a half years after cutting the young shoots of female stocks in the early spring to simulate herbivory damage by livestock such as sheep and goats on *Ephedra* plants, at the seacoast of Nan-dai-he, Qin-hwang-dao, Hebei, China. As a result, it was judged that the plants cut in the last spring scarcely put forth flower buds or female cones in the next spring in the experimental area. In addition, some plants adjacent to the experimental area also showed poor flowering. This phenomenon may be related to the character of *E. sinica* that the rhizome is long and connecting underground. Moreover, it could be judged that cutting the shoots caused damage to the growth of *E. sinica*, based on the fact that the plants in other colonies flowered normally and as well as the previous year.

Through this study, it was confirmed experimentally that herbivory damage to the plant growth of *E. sinica* by sheep was serious, as the shepherd living in the Inner Mongolia autonomy region had explained. It is thought that there is a further adverse effect when the cut position is set closer to the base of the shoot, and the *Ephedra* plants may rot and die. Actually, some shepherds said that goats used to eat *Ephedra* plants more deeply.

2. The stocks that had been cut in the early spring never sprouted new stems afterwards in the same year and did not make flower buds. Though the same stock often has some stems that delay flowering to some extent in the wild, the result of this study showed that this phenomenon did not relate to cutting the aerial part to simulate herbivory by livestock and was thought to be due to other factors. From the results of the experiment, it can be said that cut stocks photosynthesize only in the short, remaining stalks, and that the stocks show reduced vitality and are rarely able to put up flower buds in the next season. Moreover, the result of this study showed that the stocks with cut flowering shoots in early spring never produce seeds in the same year, so the influence of herbivory damage is large also from the viewpoint of reducing the output of seed for propagation.

3. The previous study⁴⁾ has revealed that *Ephedra* plants easily wither when covered by other plants, which results in a shortage of sunlight. In the experimental field in this study, it was thought that the growth of the stock was not affected by shading because few other plants that cover *Ephedra* in the summer grew in this habitat. On the other hand, in colonies where wild *Ephedra* competes with other plants, the *Ephedra* cut in the early spring may be further damaged by being covered by other plants, which results in the interruption of sunlight in the summer. It is thought that more damage to *Ephedra* growth is observed on the common steppe where many other plants grow in addition to livestock grazing, though the experiment was done in a special environment of seacoast where few other plants grew and there was no grazing.

As the *E. sinica* natural habitat examined in this study is a famous seaside resort where many people visit in summer, human disturbance during the experiment was considered. Therefore, more detailed experiments such as setting an experiment frame in the field and marking experimental plants would be difficult. Furthermore, as the development of the area surrounding this valuable natural habitat of *E. sinica* is occurring, it was judged that the possibility of the loss of this habitat in near future is extremely high.

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References

- 1) Mikage, M., Fushimi, N., Wang, L.-L. and Ebisui, S.: Studies of *Ephedra* Plants in Asia. Part 4. Morphological differences between *Ephedra sinica* Stapf and *E. intermedia* Schrenk et C.A.Meyer, and the botanical origin of Ma-huang produced in the Province of Qinghai. *J. Trad. Med.* **25** (3), 61-66, 2008.
- 2) Ministry of Foreign Trade and Economic Cooperation (MOFTEC), PRC: Notice No. 573, 1998.
- 3) Mikage, M., Takahashi, A., Chen, H.-B. and Li, Q.-S.: Studies of *Ephedra* Plants in Asia. Part 1. On the resources of *Ephedra* plants in China, *Nat. Med.*, **57** (5), 202-208, 2003.
- 4) Mikage, M., Kondo, N., Yoshimitsu, M., Nakajma, I. and Cai, S.-Q.: Studies of *Ephedra* Plants in Asia. Part 2. On the current situation of the cultivation of *Ephedra* plants in China, *Nat. Med.*, **58** (6), 312-320, 2004. Mikage, M., Motomura, H., Yoshimitsu, M., Yonekura, K. and Chen, H.-B.: Studies of *Ephedra* Plants in Asia. Part 3. The weed control problem in *Ephedra* cultivated field in China, *Nat. Med.*, **59** (3), 125-128, 2005.