

DISTRIBUTION AND NATURAL ENEMIES OF DALMATIAN TOADFLAX /*Linaria dalmatica* Mill./ AND MEDITERRANEAN SAGE /*Salvia aethiopis* L./ IN YUGOSLAVIA¹

By M. Bogavac, N. Mitić-Mužina, K. Mijatović

Institute for Plant Protection, Beograd

Weeds, Dalmatian toadflax and Mediterranean sage are members of spontaneous flora of Yugoslavia.

Research started in April 1969 shows that rather abundant populations of Dalmatian toadflax could be found in Dalmatia and on the Montenegrine Coast. In the continental part of Yugoslavia /Serbia, Herzegovina and Macedonia/ the habitats are not numerous but, some of them, especially in Macedonia, are outstanding for very abundant plants. Considerable morphological variations have been observed among specimens of Dalm. toadflax from Macedonia, Dalmatia and Serbia.

This plant in Yugoslavia grows on stony grounds and skeleton soil, on limestone substrate. On cultivated soil it is rather rare, mainly occurring in weedy vineyards, olive yards and citrus plantations. Only in the surroundings of Bitola /Macedonia/ it was found in cultivated vineyards as well. Vertical distribution extends to 1.200 m. of altitude, as it is Kruševo in Macedonia.

Distribution area of Mediterranean sage is generally Serbia, with several habitats in Macedonia. Extremely abundant populations were found in the surroundings of Zrenjanin, Prizren, Raška, as well as in the region of eastern Serbia, between Niš and Knjaževac. Most of habitats are situated in the highland of Serbia, except Zrenjanin which is situated on the Pannonian Flat. Similarly to Dalm. toadflax, Med. sage has also been found on deserted or completely uncultivated soil, along roadsides and on heaths. It is present on various soil types, and most frequent on delluvial deposits of sand and clay, on "smonitsa", limestone and chernozem.

Since both the plants are generally present on barrens, skeleton and unsuitable soils for agricultural production, and being on a tolerant level on fertile land, they are not of economic importance as weeds in Yugoslavia.

Dalm. toadflax is a perennial plant. It has the vegetative and generative reproduction. Aged plants are qualified by a very branching root system, with outstanding tap-root, which is more or less woody. On lateral roots, with horizontal position, there are vegetative buds from which numerous flower stems grow, especially after mechanical removal of aereal plant parts. In the area of root neck, usually in spring and fall, even 10 and more sprouts can also be found. Generative reproduction is also distinct, as regards to Dalm. toadflax having 3 main periods of flowering in Yugoslavia - spring, summer and fall - with abundant fructification. However, it can be observed that the maximum number of seed capsules are produced in fall.

Plants of Dalm. toadflax from the surroundings of Bitola and other habitats in Macedonia have the highest growth, very branching stems and

¹ Presented at the 2nd. International Symposium on Biological Control of Weeds, Rome, Italy Oct. 4-7, 1971.

a strong root-system, in which tap-root, at root crown, extends even to 5 cm in diameter.

Mediterranean sage is a biannual plant, with seed maturation in the late July. After completed flowering and seed maturation plants get dry soon. Besides generative reproduction, Med. sage has also the capacity of regeneration and formation of new stems mostly in the case when the main is destroyed. This property permits Med. sage carry-on on pasture.

Phytophagous insects of Dalmatian toadflax

From a relatively rich fauna of phytophagous insects, developing on Dalm. toadflax, the species outstanding for their broad distribution and dense populations are following: Gymnetron antirrhini Payk., Gymnetron netum Germ., Brachypterolus pulicarius L., Eupithecia linariata F., Calophasia casta Bkfl., Calophasia lunula Hufn., Stigmatophora serratella Tg., Agapanthia violacea Fabr., Eurytoma sp. and Chrysomela Rossia Illig.

Species belonging to the genus Gymnetron are the most important, in relation to distribution, population density and the role in Dalm. toadflax population reduction. On the territory of Yugoslavia a number of species belonging to this genus have been detected, but the most important reducing agents of Dalm. toadflax are Gymnetron netum and Gymnetron antirrhini. The presence of G. netum has been registered on all habitats of Dalm. toadflax. In climatic conditions of Yugoslavia it develops three generations yearly. Larvae are present in green capsules, and adults in capsules containing mature seeds. It is characteristic of this species that up to four individuals can complete development within one capsule. Each individual develops in a separate section of the capsule, whereas seeds from another part of the capsule are left untouched. Thereafter, capsules with the development of a single larva, produce seeds, though at a somewhat reduced rate. The most dense population of G. netum occurs during summer fructification, when the number of attacked capsules exceeds 80%.

No large-scale occurrence of entomophages, associated with this species, was detected. Parasitic wasps from genus Habrocytus /Chalcididae/ generally occur. In 1971, a species from the family Inchneumonidae was also obtained from some localities.

Distribution of Gymnetron antirrhini is not as wide as that of G. netum. The presence of dense populations was exclusively detected on the localities of Macedonia. Gymnetron antirrhini has a single generation yearly. Adults of new generation occur in July, i.e. in the period of the second fructification of Dalm. toadflax. One single individual is developed per capsule. All seeds in the capsule are destroyed. The important suppression role of this insect species in Dalm. toadflax reduction in 1971 was recorded on the localities of Drenovo Gorge and Katlanovo, with over 90% destroyed capsules.

In the group of phytophages attacking reproductive organs, the species Brachypterolus pulicarius and Eupithecia linariata were also detected. Both species have a very wide distribution. They are present on all localities of Dalm. toadflax. Brachypterolus pulicarius is outstanding for its population density. Larvae, or caterpillars of both of these species feed on pollen-sacs and pistils, but no data have been available for the present on the degree of their reducing capacity of Dalm. toadflax generative reproduction.

In 1971, on the localities of Mostar and Petrovac-on-Sea, another phytophage was detected within Dalm. toadflax seed-capsules. This is a species from genus Eurytoma. Sites of their emergence from seed-capsules where this wasp developed, are markedly smaller as compared to the sites of emergence of G. netum adults from seed-capsules.

Species from genus Calophasia belong to the group of very voracious phytophagous, which caterpillars feed on leaves of Dalm. toadflax and other species from genus Linaria. During two year research, we found that Calophasia casta mainly occurs on Dalm. toadflax in Dalmatia, Herzegovina and Macedonia, whereas in Serbia Calophasia lunula is also present.

In our climatic conditions, Calophasia casta develops three incomplete generations yearly. It overwinters as the third, and sometimes as the second generation pupa. Caterpillars occur in May, June and September. Young caterpillar instars remain within flowers of Dalm. toadflax. In summer-time, at high temperatures, there are also grown caterpillars remaining within the flower by day. Young caterpillars were observed to feed on reproductive parts that can be their only feeding source up to the third instar. Meanwhile, as far as aged caterpillars are concerned, leaving flowers at twilight time, this is considered to be the way of their daily protection against high summer temperatures.

Populations density of Calophasia casta has been varying from year to year, which important agents are entomophagous insects and pathogens. On the localities of Mostar and Petrovac-on-Sea, rather dense populations have been recorded this year, as well as a large number of parasitized and affected caterpillars. Three tachinids were found as entomophagous, being: Tachina praeceps Meig., Spaggosia media Rond. and Masicera cucullinae R.D., as well as a species from genus Ascogaster.

Among insects developing on the root or stem of Dalm. toadflax /species from genera Mecinus, Gymnetron, Stagmatophora, Oecanthus and Agapantia/, the suppression role of Stagmatophora serratella and Agapantia violacea should be pointed out.

Stagmatophora serratella was detected on all habitats of Dalm. toadflax, but with high variations in population density. Meanwhile, a constant high population density was found on plants of Linaria genistifolia, mostly on the localities of the Ibar Valley. At the same time, these are very rich and large habitats of Linaria genistifolia. The number of affected plants is regularly over 50%. Even 10 caterpillars were very often found on a plant with a strong root neck. This species develops 2 to 3 generations yearly, and overwinters as caterpillar. Moths live more than one month. Females are rather fecund. Laid eggs exceed 100. Eggs are laid in leaf axilla, on lower plant parts. Embryonal development lasts 60 to 8 days at the temperature of 30°C. Small but very vigorous caterpillars penetrate the stem soon after emergence. At the initial stage they are present in the upper parts of the stem, but in the course of development they gradually move downwards, so that most of caterpillars complete their development in bark of the root neck or deeper in the root itself.

Agapantia violacea, the phytophagous from the family Cerambycidae has a wide distribution. It was not observed in a large number on any of the localities till September this year. Meanwhile, in September, over 50% plants containing larvae of this phytophagous were found on the habitat of Dalm. toadflax near Bitola. As to feeding capacity of its larvae and their developing sites, this species could be a control agent of Dalm. toadflax and other plant species from genus Linaria.

On the locality of Bitola, we found adults of Chrysomela Rossia Illig. on Dalm. toadflax plants in May 1971. They were diapausing in the insectary in Belgrade till September. Approximately on September 15, they were activated, starting to feed, copulate and oviposit. Eggs were laid all around plants, and mostly at the bottom of the cage. They are also present on plant leaves. The role of this insect might have been important, if it had appeared in a more dense population.

On plants of Dalm. toadflax, dense colonies of aphids were also found, on sub-terranean and aerial plant parts. Their role in reduction

of the plant vitality and capacity of the vegetative and generative reproduction was important.

Besides insects, we also found pathogens to have participated considerably in population reduction of Dalm. toadflax in Yugoslavia. Among these, the occurrence of Sclerotinia sp., Didymaria linariae and Erysiphae taurica should be pointed out. The role of Sclerotinia sp. was extremely important, causing decay of a large number of plants of Dalm. toadflax and Linaria genistifolia. On some localities, even over 50% plants were affected by die-back.

Phytophagous insects of Mediterranean sage

In Yugoslavia, Mediterranean sage is also the host plant of a large number of phytophagous insects. Opposite to Dalm. toadflax, a very low number of species were found on it developing on reproductive parts. For the present we have only found Meligethes vidiatus Storm. /Nitidulidae/, Chloridea peltigera Schiff. /Noctuidae/ and Eurytoma Nikolskaya /Chalcididae/.

The species Meligethes vidiatus is the first in relation to distribution area and population density. Its adults emerge in the period of flower buds formation, and are found till the end of July. Dense populations of the species are found on all localities.

Eurytoma Nikolskaya also has a wide distribution, but a low population level. On the localities of its more frequent presence, the percent of affected seeds did not exceed 10%.

Chloridea peltigera, the polyphagous cutworm, was shown to be an important control agent of Med. sage. Its distribution is rather wide but it has occurred on few habitats in a large number. More dense populations were registered at Staro Gradsko /Priština/ in 1970. Populations have been almost completely destroyed on the same localities in 1971.

Besides already mentioned species, a rather dense population of Phrydiuchus tau Warner and Stagmatophora pomposella Zell. was also found on Med. sage.

The former feeds and develops on leaves and roots of Med. sage, and the latter exclusively on leaves.

Phrydiuchus tau in Yugoslavia is mostly present on Med. sage though in 1971 a certain number of adults has also been found on rosettes of Salvia sclarea L. It has a very wide distribution. Its population density is uneven. It is not correlated to the density of Med. sage on certain habitats. On plain grounds Zr̄njanin and Staro Gradsko on which Med. sage, was abundant Phrydiuchus tau was rather rare. A numerous population was found on the habitats with dispersed and permeable soils /Doljevac, Arnoljevo/. An extremely dense population was observed on the locality Doljevac, where over 90 larvae were found on one root only, of biannual rosette, and 40 adults on a flowering plant. Its feeding needs and the way of causing damage are such as not essentially reducing the plant capacity of further growth and increase. It was found by a laboratory test that there were the minimum feeding needs of adults in the period of complementary feeding and sexual maturation. Besides, Med. sage has an intensified capacity of regeneration and lateral shooting. In the swarming time, adults mostly feed exclusively on top leaves, what, according to our observations, does not influence seed yield reduction. All these observations should, anyway, be proved by a more fundamental experimental study.

Investigations to date have shown that larval role as reducing agents is still lower. We were suggested this by the fact that we found even over 90 larvae on a rosette, but the plant did not show any depres-

sion symptoms. There were several larvae per leaf nerve or pedicel, without any visible symptoms of desiccation on the leaf itself. Besides, larval capacity of development in the oldest, dry leaves of the rosette, or on desiccated plants due to disease or attack by mites, points to their ability also to feed on organic matter in decay.

Among phytophagous insects detected on Med. sage, Stigmatophora pomposella was observed by dense populations as early as the first year of research. The maximum density was found in the region of Zrenjanin, and S. pomposella was detected on almost all localities of Med. sage presence. It overwinters as caterpillar instar and has three generations per year, but a part of population is also able to develop the fourth. This phytophagous insect is the host of a parasitic wasp from genus Apanteles and of a species from genus Ascogaster. These parasites have an important suppression role in population reduction of S. pomposella. In the overwintering generation, the percent of parasitized caterpillars is 36,81%, and even over 40% in the summer generation.

This is a relatively small insect. Thereafter, its feeding needs are of the corresponding proportions. Injuries caused by feeding caterpillars to Med. sage leaves cannot destroy a very big leaf mass of biannual plants even by a rather severe attack. Neither can they damage it more seriously and disturb the process of photosynthesis. Meanwhile, with annual plants, a rather severe damage can be caused by caterpillars. If they are in a rather high density, they are able to destroy the maximum of the leaf area, causing rosette desiccation. Anyway, this is also one of the problems to be considered more in further research.

Besides a large number of insects, a mite species - Aceria neosalviae Keifer has been found rather frequently on Med. sage in Yugoslavia. On some habitats /Zrenjanin, Staro Gradsko, Priština/, it has suppression role in reduction of young Med. sage.

On Med. sage plants, symptoms of virus disease were found on two localities. A virus was isolated, but it has not been identified, neither were they important as reducing agents of Med. sage.

Conclusion

On the base of investigations to date of the phytophagous insect fauna of Dalm. toadflax /Linaria dalmatica Mill./ and Med. sage /Salvia aethiopis L./ and their role in reduction of these plant species, we could come to the following conclusions:

The insect fauna of Dalm. toadflax in Yugoslavia is relatively rich in relation to the number of the species present. Among detected species there are, also such that could be promising control agents of this plant, by feeding capacity or population density /species from genus Calophasia, Gymnetron etc./.

The number of phytophagous species detected on Med. sage is somewhat lower. Phrydiuchus tau and Stigmatophora pomposella are outstanding for distribution and population density. Meanwhile, their importance in the host reduction has not been encouraging for the present. A somewhat more promising control agent that could be eventually used for biological control of this weed, is the mite Aceria neosalviae, but more fundamental research of this phytophagous insect is still in progress.

References

- Alex, J.F. 1962. The taxonomy history and distribution of *Linaria dalmatica*. - Canadian Journal of Botany, Vol. 40.
- Andres, L.A. and A.Rizza. 1965. Life history of *Phrydiuchus topiarius* /Coleoptera: Curculionidae/ on *Salvia verbenacea* /Labiata/. - Ann. Entomol. Soc. Amer. Vol. 58, pp. 314-319.
- Andres, L.A. 1966. Host Specificity Studies of *Phrydiuchus topiarius* and *Phrydiuchus* sp. - Journal of Economic Entomology, Vol. 59, No. 1, pp. 69-76.
- Bucher, G.E., Harris, P. 1968. Virus diseases and their interaction with food stresses in *Calophasia lunula* Hufn. J. Invest. Path. Vol. 10, No. 2.
- Domac, R. 1967. Ekскурzijska flora Hrvatske i susjednih područja, Zagreb.
- Grebensikov, O. 1950. O vegetaciji Sićevačke klisure - Glasnik Prirod-njačkog muzeja Srpske zemlje, ser. B. knj. 3-4, Beograd.
- Harris, P. 1961. Control of Toadflax by *Brachypterosus pulicarius* L. /Coleoptera: Curculionidae/ in Canada - The Canadian Entomologist, Vol. XCIII, No. 11, pp. 977-982.
- Harris, P. 1963. Host Specificity of *Calophasia lunula* Hufn. /Lepidop-tera, Noctuidae/ - The Canadian Entomologist, Vol. 95, No. 1, pp. 101-105.
- Karny, M. 1963. The possibilities of *Calophasia lunula* Hufn. /Lep. Noctu-idae/ in the Biological control of Toadflax, *Linaria vulgaris* Mill. - Technical Bulletin of The Commonwealth Institute of Biological Control, No. 3, pp. 1-27.
- Kock, F. 1966. Bionomische und ökologische Untersuchungen zur Entomofauna an *Linaria vulgaris* Miller /Scrophulariaceae/ - Zeit. für Angewandte Entomologie Band 58/Heft 3 pp. 193-252.
- Lange, A.W. 1958. Dalmatia Toadflax - A possible rival of Goatweed as a Serious Range Weed. Weeds, Vol. 6, No. 1, Geneva, New York.
- Luis-Marie, R.P. 1955. La Linaire vulgare dans le Québec, Canada-II Un contrôle entomologique spontané - La Revue d'Oka, Vol. XXIX, No. 4.
- Malicki, H. 1967. Climatological and ecological aspects of the geograph-ical distribution of the genus *Calophasia* Steph. /Lep., Noctuidae/ - Technical Bulletin of The Commonwealth Institute of Biological Control, No. 8, pp. 103-117.
- Pančić, J. 1874. Flora Kneževine Srbije, Beograd.
- Perkins, D. 1966. Report of Yugoslavia - Turkey Field Trip for Collection of Insects on *Linaria* sp. / Scrophulariaceae / and *Tribulus terrestris* /Zygophyllaceae/.
- Petrović, S. 1882. Flora okoline Niša, Beograd.
- Smith, J.M. 1957. Notes on Insects, Especially *Gymnaetron* spp. /Coleop-tera: Curculionidae/, Associated with Toadflax, *Linaria vulgaris* Mill. /Scrophulariaceae/, in North America - The Canadian Entomolo-gist, Vol. 91, No. 2.
- Warner, R.E. 1969. The Genus *Phrydiuchus*, with the Description of Two New Species /Coleoptera: Curculionidae/ - Ann. of The Ent. Soc. Am. December 1969, pp. 1294-1304.