Skeletonweed in Eastern United States

by

Clyde F. Reed

Skeletonweed or gum-succory (Chondrilla juncea L.) is a vigorous perennial composite, native to Europe and western Asia, where it is of comparatively importance, being only rarely mentioned as attaining the status of a weed. It was probably introduced into Eastern United States from Europe in the early nineteenth century as a weed-seed in grains.

The purpose of this paper is to review the introduction and spread of skeletonweed in Eastern United States, to provide a complete description of the plant, with an illustration, to describe its life-cycle, to discuss ways being tried for control and eradication of this noxious weed, and to provide an annotated list of herbarium specimens collected in the area studied.

Introduction and spread of skeletonweed

For more than 100 years skeletonweed has been collected in Eastern United States, usually as a weed of waste lots, along roadsides and railroads and to a limited extent in fields and pasturelands. Most of the early records of skeletonweed in this region are from weedy situations, as vacant lots, filled-in areas and along roadsides. In the last 30 years it has become more frequent along railway right-of-ways, as Wilmington, Delaware to Cape Charles, Virginia; from Baltimore to Washington, D.C., and then to Fredericksburg and southward; Washington, D.C. up the C. & O. R.R. along the Potomac River to Allegany County, Maryland; along other railroad to Front Royal, westward into West Virginia; along railways in southern New Jersey; in any of these areas becoming vast patches. Entire shaley hillsides and upland pasturelands in western Virginia and eastern West Virginia have been taken over by this weed.

During World War I (about 1917) skeletonweed was introduced into the Riverina region of Australia and thence spread to all the major wheat-producing regions of that continent, causing an economically serious weed problem. It was first found in Western Australia at Ballidu in 1963. Much research and experimentation has been carried in Australia during the past two decades in an effort to control this weed by chemical and biological means. (See bibliography).

Skeletonweed has been recently introduced into western United States, probably from Australia, and now covers vast areas from Washington and Idaho southward, thus becoming an economically important weed there also. Several United States governmental agencies have begum to study ways to control or eradicate this plant, especially in the wheat-growing areas of western United States.

Description and Illustraion

<u>Chondrilla juncea</u> L. Skeletonweed, Gum-succory

Biennial or perennial, with taproot, forming a rosette of leaves the first year; stem 0.3-1.5 m. tall, virgate branching, bristly-hairy or hispid, herbage otherwise glabrous; stems and roots exude white gum basal leaves runcinate-pinnatifid to nearly entire, often deciduous, 5- 13 cm. long, 1.5-3 cm. broad; cauline leaves few, reduced, linear, 2-1 cm. long, 1-8 mm. broad; flowering heads subsessile or short-peduncula 1-1.5 cm. long, scattered on nearly leafless branches; involucre white- tomentose, cylindrical, 9-12 mm. high, of several narrow linear equal phyllaries and a row of small bractlets at base; ray-flowers bright yellow; achenes terete, the body about 3 mm. long, several-ribbed, smooth below, roughened at summit by little scaly projections, from which arise an abrupt slender beak; pappus copious, of very fine soft capillary bright-white bristles. Fl. July-Sept.

Fields, roadsides, waste places, shaley hillsides and along railroads.

Native to Eurasia, from Iberian Peninsula through southern Europe, Asia Minor and the Caspian Sea region to the Altai Mountains and eastw to Mongolia; North Africa (Algeria and Tunisia); introduced widely in Australia and North America (Eastern United States from New York and New Jersey to Virginia and Georgia, west to Michigan; western United States from Washington and Idaho and southward).

Life-cycle of Skeletonweed*

Skeletonweed requires a habitat well-exposed to sublight and a well-drained soil, either sandy or shaley, and rather acid. The most frequent habitats in Eastern United States where the author has observ stands have been in Coastal Areas on sand dunes, sandy wastes and fiel in Piedmont Areas along railways on ballast, and in the mountainous regions on shaley hillsides and well-drained pasturelands.

Skeletonweed seed germinate shortly after the seeds are produced, in October and November in the Northern Hemisphere, in April or May in Australia, forming a rosette of lance-shaped juvenile leaves which may vary from slightly lobed to progressively more deeply lobed or dentate Tips of the lobes always point towards the base of the leaf. Rosettes can grow, under most favorable conditions, to a diameter of 37 cm. or more and vary from dark green to purplish in color. Plants remain in the rosette stage over winter.

In the spring, an erect stiff stem, branched almost from the base develops from the center of the rosette. For the most part the stem i smooth except for a thick covering of bristles for about 10 cm. just above the rosette. Leaves along the flowering scape are few, widely spaced, strap-shaped to sometimes linear, and unlobed. Plant parts when broken exude a whitish acrid juice. Rosette-leaves die off as flowering commences in mid-summer. Stem-leaves are persistent almost

* Cuthbertson, E.G. Bull. 68, N.S.W. Dept. Agric., Agric. Res. Inst., Wagga Wagga. 1967.

to maturity, and then fall, leaving a lax bare skeleton-like twiggy stem by late autumn. The small flower-heads occur either singly or in groups of twos or threes at the tips and along the branched stems. Flower-heads consist of 8-12 florets, each with one bright yellow straplike petal. Each floret produces a single achene, roughened near its apex by small toothlike projections and surmounted by a crown of five fused scales. A slender beak as long as or longer than the achene arises from the crown and bears a pappus of numerous toothed bristles. Marked plants have produced from 2,000 to 15,000 achenes per plant per season.

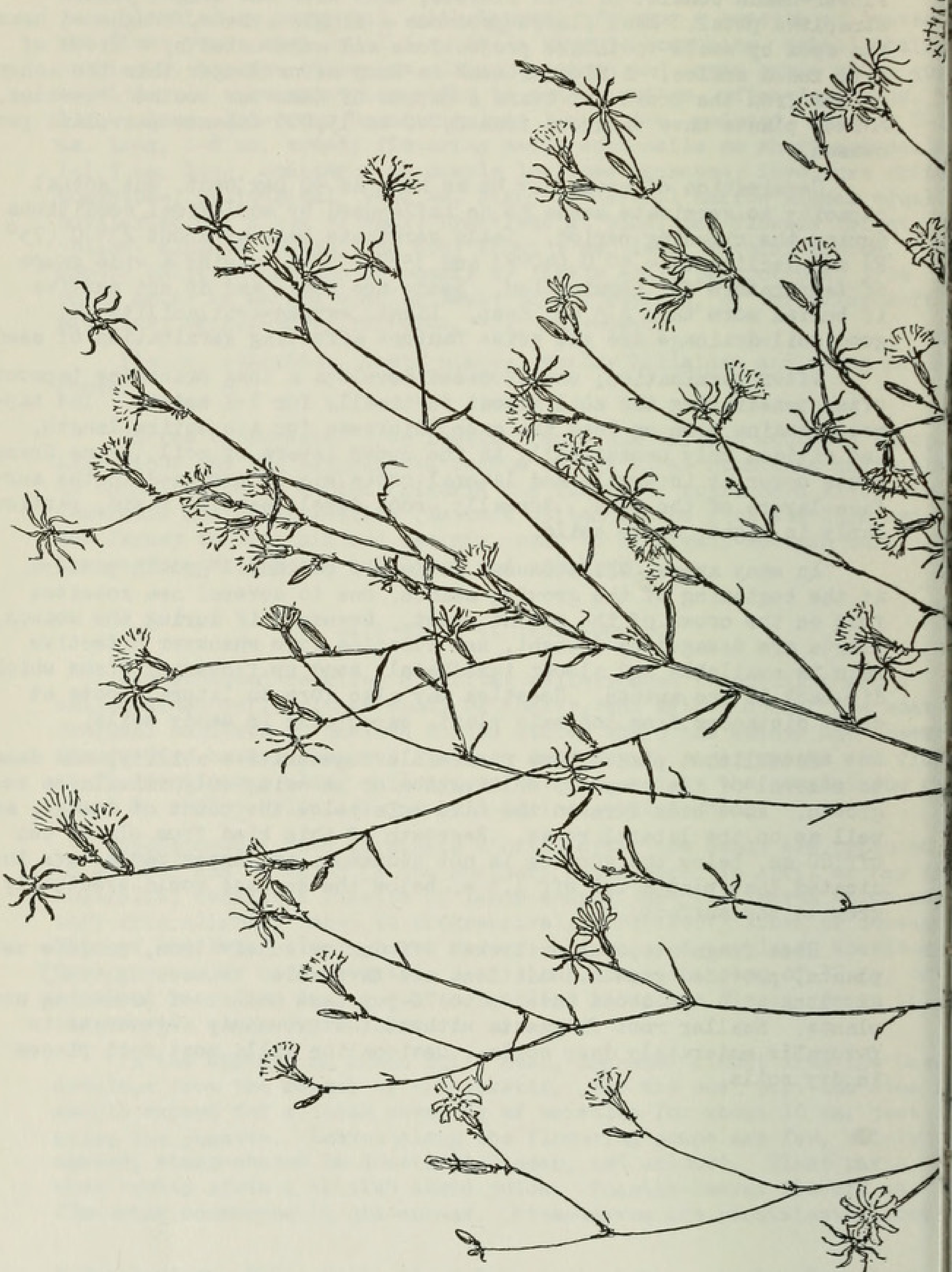
Germination of seeds may be as high as 90 per cent, but actual capacity to germinate seems to ne influenced by ecological conditions during the ripening period. Seeds germinate best at about 23° C (75° F) and decline to 4.5° C (40°F) and 35°C (95°F), giving a wide range of temperature for germination. Seeds are small and do not survive if buried more than 2.5 cm. deep. Light, oxygen-availability and good soil-drainage are the prime factors affecting germination of seeds.

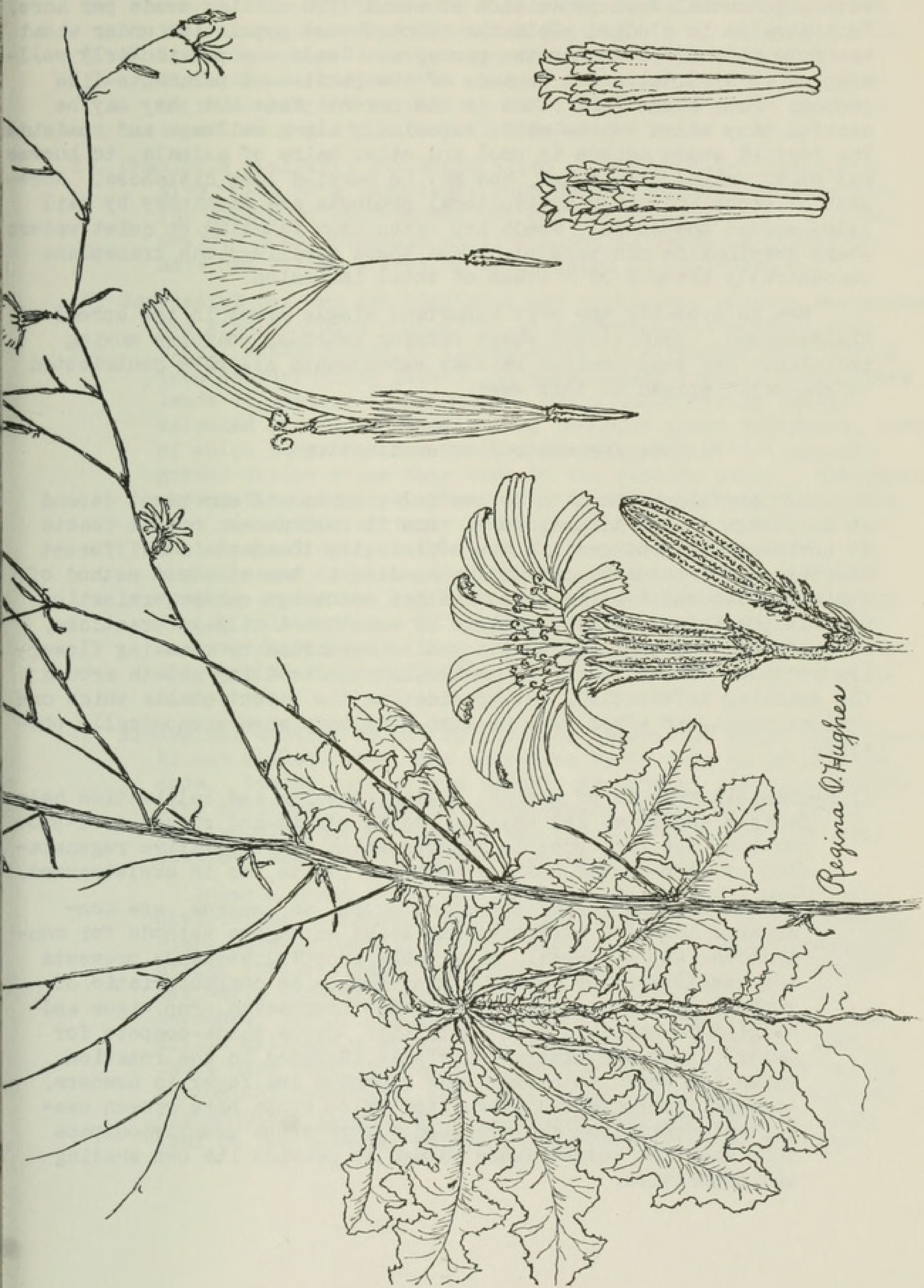
After germination, skeletonweed develops a long branching taproot, often penetrating the soil almost vertically for 1-2 meters. The taproot remains more or less the same thickness for its entire length, and divides only occasionally in the upper layers of soil. Fine branch-roots occur at intervals and lateral roots may be produced in the surface layers of the soil. Normally, root development is rapid, particularly in light, sandy soils.

In many areas, skeletonweed follows a perennial growth pattern. At the beginning of the growing season, one to several new rosettes form on the crown of the parent plant. However, if during the season, plants are damaged by drought, new rosettes form whenever effective rain is available and almost immediately send up flowering stems which die back in the autumn. Rosettes may also form on lateral roots at short distances from the main plant, especially in sandy soils.

Established plants have remarkable regenerative ability, and damage to removal of the crown by cultivation or browsing only stimulates regrowth. Root buds form on the main axis below the point of damage, as well as on the lateral roots. Regrowth of this kind from plants cut off 80 cm. below the surface is not uncommon, and experiments have indicated that plants cut off 1.5 m. below the surface would eventually grow to the surface.

Root fragments, cut or broken off during cultivation, produce new plants, provided growth conditions are favorable. Pieces up to 23 cm. long with the crown have up to 70 per cent chance of producing new plants. Smaller root fragments without the crown may regenerate in favorable moderately damp soils. Desiccation kills most root pieces in dry soils.




Regina O. Hughes

Seeds may be spread by wind, water, animals or man. It has been calculated that each flowering stem bears about 200 flowers per season, with a potential seed production of about 1700 million seeds per acre. In Australia in studied plots the average weed population under wheat was more than 800,000 rosettes per acre. Seeds are particularly well-adapted to wind dispersal because of the persistent parachute-like pappus. Most seeds fall close to the parent plant but they may be carried many miles by the wind, especially along railways and roadsides. The toothed seeds adhere to wool and other hairs of animals, to hooves and other animal structures, and may be carried long distances. Movement of stock and other agricultural products and machinery by rail helps spread the seeds. Seeds are often seen floating on quiet waters, where germination can take place and these seedlings can transplant successfully after 1 or 2 weeks of total immersion.

Man is probably the most important single agent in the spread of skeletonweed. Traditional wheat farming methods, roadside mowing techniques and well-drained railway embankments all have contributed to the rapid spread of this weed.

Methods for control or eradication

Successful eradication or control programs of any plant depend on knowledge of its life-cycle -- how it reproduces, how it reacts to environmental changes and how efficiently to adapts to different habitats. For annuals, preventing seeding is the simplest method of control. Also cultivation methods which encourage early germination make it possible to kill seedlings by subsequent tillage practices. For. perennials, seed production can be curtailed by removing flowering portions of the plant, or destroying the seedling growth around the existing infestation, but eradicating the parent plants which can produce seed year after year is also necessary when economically possible.

I. Mechanical Methods of hoeing, mowing, burning and cultivation help destroy seedlings and shallow-rooted plants and reduce seed-production, but only promote fragmentation and vegetative regeneration of deep-rooted well-established plants, as in skeletonweed.

II. Crop-rotation and use of competing crops, as lucerne, are considered the most effective and least expensive methods for controlling skeletonweed. A suitable cropping sequence prevents the development of specific weed groups so characteristic of monoculture, while at the same time increasing crop vigor and helping to maintain soil fertility. Crops which compete for water, light and mineral nutrients included in the rotation cause the weeds to become less vigorous and fewer in numbers. Lucerne, subterranean clover and pulse crops have proven useful in controlling skeletonweed. Such crops usually outpace this weed and become dense enough to provide its own shading and protection.

III. Grazing animals, especially sheep, greatly reduce plant density of skeletonweed. In fact, investigations reveal that excessive cultivation and the absence of stock on farms was the main cause of skeletonweed getting out of hand in Australia. Sheep as close grazers clean up low-growing weeds as skeletonweed better than cattle. Fortunately, skeletonweed is palatable and nutritious from the rosette stage up until the flowering stage is well-developed.

IV. Chemicals available for eradication of skeletonweed are expensive. But more important, such chemicals sterilize the soil for growth of crop-plants and can not be applied on a large scale. Some chemicals applied along railways as herbicides have had little effect on eradication of skeletonweed.

V. Successful pasture establishment and subsequent pasture management can give adequate control of skeletonweed. As a sun-loving plant, skeletonweed it ill-equipped to withstand competition from sward-forming plants, as pure clover swards. Overgrazing leads to pasture degeneration, while undergrazing permits selected grazing of species and promotes grass dominance, both of which encourage survival of skeletonweed. Continuously grazed fallow keeps this weed in the rosette stage. Rhizomatous perennating plants such as skeletonweed need only to replace that proportion of their total population which is equal to their annual death rate to maintain population levels. In skeletonweed, such replacement occurs by seed, by multiple rosette production and by regeneration of root-fragments cut during cultivation. If these techniques are sufficient to achieve replacement, then total destruction of seeding capacity has no biological control effect on established populations.

VI. Biological control by use of insects, several of which are known to eat skeletonweed, has proven to be of only minor importance. Insect populations usually decline as the weed population declines. Also, it is necessary to maintain a small weed population to maintain the insect population. So that complete eradication is never quite attained.

Insects under study for possible biological control of skeletonweed include a buprestid stem and root borer (Sphenoptera faveola Gebl.), a tortricid moth (Oporopsamma wertheimsteini Rbl.), aphids (Uroleucon chondrillae), an eriophylid gall-mite (Aceria chondrillae Can. -- Wapshere, 1971 and Morschel, 1972), Chondrillobium blattnyi Pint. and the Chondrilla gall-midge (Cystiphora schmidtii -- Morschel, 1972). There have been studies to determine the degree of effective biological control of skeletonweed by the use of the insects (Sphenoptera faveola and Oporopsamma wertheimsteini) which feed on the material stored in the overwintering rhizomes.

VII. Biological control by parasitic fungi has been suggested and is being experimented with (Carter, 1972). Throughout the natural range and within introduced populations of skeletonweed, the rust-fungus, Puccinia chondrillina Bubak & Sydow, has been reported. This fungus appears on the young rosettes in autumn and spring as uredosori, and severe infestations can occur in the field leading to the death of the rosette. When the flower shoots develop in mid-spring, the uredosori appear on them and are replaced by teleutosori which produce the over-wintering spores by July (France) onward. A heavily infested plant is, at the end of the season in September, completely covered by brown extruding sori, at which time few buds appear and the plant dies before seeding. The rust does not attack the underground portion of the plant which remains to produce new rosettes in autumn and spring. These new rosettes often become attacked by new uredosori.

Other fungi being studied for control: Ascochytella chondrillina Sacc. and Leveillula taurica (Lev.) Arnaud (Wapshere, 1971). Many other fungi have been reported on living and dead portions of skeletonweed.

A list of the species of fungi and literature citations describing them follows for those persons interested in researching the possibility of them for biological contol of skeletonweed.

Puccinia chondrillina Bubak & Sydow   Chondrilla Rust, the most widespread of the fungi naturally found on skeletonweed.

Syn.: Uredo chondrillae Opiz (nom. nud.)
Bullaria chondrillina (Bubak & Syd.) Arth. & Mains
Puccinia chondrillae Corda (p.p.)
Puccinia prenanthis (Pers.) Fuckel (p.p.)

Arthur, J.C. Manual of Rusts in United States and Canada. 438 pp. 1934. (D.C., Md. Va.).

Arthur, J.C. and E.B.Mains North. Amer. Flora, 7(7): 482-515. 1922. (D.C., Md., Va.).

Beltran, F. Real Soc. Espanol. Hist. Nat., Spec. 50th. Anivers.: 242-271. 1921. (Spain-on lvs., st. and invo.)

Bontea, V. Parasitic and saprophytic fungi of Rumania. 637 pp. 1953.

Bremer, Hans, H. Ismen, G. Karel, H. Ozken & M. Ozkan Istanbul Univ. Fac. Sci., Rev. Ser. B. 12: 307-334.1947.

Bubak, Fr. and J.E. Kabat Oesterr. Bot. Zeitschr. 55: 73-79. 1905. (Austria, Tyrol).

Constantineanu, I.C. Jassy Univ. (Rumania). Ann. Sci., 10: 314-460. 1920. (Rumania - on living stems).

Gamalitskaia, N.A. Akad. Nauk Kirgiz SSR, 175 pp. 1964. (Cent. Tien-shan, Tadzhik, SSR).

Gobelez, M. Mycopath. et Mycol. Appl. 19: 296-314. 1963. (Turkey).

Goncalves Da Cunha, A. Bol. Soc. Broteriana (Coimbra), Ser. II. 11: 169-365. 1936. (Portugal).
Gonzalez Fragosa, Romualdo Mus. Nac. Cien. Nat., Trab. Ser. Bot. 15: 1-267. 1918. (Spain).
Hasan, S. and A.J. Wapshere Ann. Appl. Biol., 74: 325-332. 1973.
Hazslinszkya, Fr. Math. es Termeszettudom Kozlemenyek, 15: 1-22. 1878. (Hungary).
Hruby, J. Hedwigia, 67: 150-213. 1927; l.c., 68: 119-190. 1928-1929. (Europe).
Jacky, Ernst Zeitschr. für Pflanzenkrank, 9: 263-295. 1899.
Kalymbetov, B. Akad. Nauk SSSR, Bot. Inst. Trudy Ser. II. Sporovye Rast. 11: 175-312. 1956. (Turkmen, SSR).
Klebahn, H. Kryptogam der Mark Brandenburg, 5A: 401-604. 1913. (Germany - on lvs., branches and stems).
Moesz, G. Budapest Magyar Nemzeti Muz. Ann. Hist. Nat. 33 (Resz. Bot.): 127-200. 1940. (Hungary).
Moskovitz, S. Bull. Jard. Bot. Kieff, 16: 17-87. 1933. (Ukr.).
Panfilova, T.S. and N.I. Gananenko Akad. Nauk Uzbek SSR, Tashkent. 208 pp. 1963. (Uzbek - uredial and telial stages on leaves, petioles and stems).
Pantidou, M.E. Fungus-Host Index for Greece. Benaki Phytopathol. Inst., Kiphissia, Athens. 382 pp. 1973.
Picbauer, R. Belgrade Univ. Bot. Zaveda i Bste Glasnik, 1: 60-74. 1928. (Yugoslavia - on stems and leaves).
Pospelov, A.G., N.G. zaprometov and A.A. Domasheva Fungi of the Kirghiz SSR, Frunze, 128 pp. 1957.
Ranojevic, N. Hedwigia, 77: 233-242. 1938. (Macedonia)
Saccardo, P. Sylloge Fungorum, 17: 311-312. (Germany, Italy, Bohemia, France, Portugal - on leaves, petioles & stems).
Savulescu, Tr. Acad. R. P Romane An. Ser. A: 1-36. 1949. (Rumania -- on leaves and stems).
Sibilia, O. Ann. Bot. 21(2): 290-306. 1938. (Italy).
Sousa da Camara, E., A. Lopes Branquinho de Oliveira and C. Gomez da Luz Agron. Lusitaniae (Portugal), 2(2,4): 113-167, 237-377. 1940. (Portugal).
Sydow, H. and P. Sydow On the Fungus Flora of Tirol. Oesterr. Bot. Zeitschr. 51: 11-29. 1901.
Sydow, H. and P. Sydow Contributions to Fungus Flora of Portugal. Broteria, 2: 149-155. 1903.
Sydow, P. and H. Sydow Monograph Uredinearum. Vol. I: Genus Puccinia. 972 pp., illus. Lipsiae. 1904. (on lvs. pet.& st.).
Thuemen, F. v. Journ. Sci. Math. Phys. et Nat. (Lisbon), Ser. I. 6: 230-253. 1878.
Unamuno, P.L.M. Bol. R. Soc. Espan.Hist. Nat., 28: 195-202, 495-506. 1928; l.c., 30: 207-215. 1930; l.c., 31: 85-96. 1931. (Spain).
Unamuno, P.L.M. Madrid Jard. Bot. An. 1940(1): 9-58, illus. 1941. (Spain).
Voronikhin, N.N. Tiflis Kavakazskago Muz. Izv. 10: 1-35. 1916. (Caucasus - telial stage).

Darluca filum (Biv.) Cast. in Sacc.
d'Almeida, J.V. and M. Souza da Camara Bol. Soc. Broteriana (Coimbra), 24: 150-213. 1909. (Portugal).
Saccardo, P. Sylloge Fungorum, 13:305. 1898. (leaves).
Unamuno, P.L.M. Bol. R. Soc. Espan. Hist. Nat. 31(2): 85-96. 1931. (Spain).

Ascochytatella chondrillina Petrak
Hruby, J. Zemled. Misul, Sofia, 2(3): 65-85. 1930. (Bulg.).

Puccinia flosculosorum (Alb. & Schw.)
Winter, G. Hedwigia, 19: 33-45, 53-60. 1880. (Europe).

Sclerophoma chondrillina
Hruby, J. Hedwigia, 68: 161-190. 1928. (Europe).

Phyllosticta chondrillina Gz. Frag.
Gonzalez Fragoso, R. Rev. Real Acad. Cien. (Madrid), 15: 681-702, 709-738. 1917. (Spain - on dead leaves).

Plenodomus chondrillae Died.
Diedicke, H. Ann. Mycol. 9: 137-141. 1911. (Germ. -on dead stems).

Erysiphe communis (Wallr.) Link
Bontea, V. Parasitic and Saprophytic Fungi of Rumania. 637 pp. 1953.

Leptosphaeria mirabilis Niessl
Niessl, G.v. Hedwigia, 20: 97-100. 1881.
Saccardo, P. Sylloge Fungorum, 13: 305. 1898. (stems).

Leptosphaeria bella Pass.
Saccardo, P. Sylloge Fungorum, 13: 305. 1898. (stems).

Macrosporium commune Rabenh.
Moskovetz, S. Bull. Jard. Bot. Kieff, 16: 17-87. 1933. (Ukraine).

Dothidea appendiculata Delacroix
Syn.: Dothidella appendiculata (Delacr.) Har. & Briard.
Diplochorella appendiculata (Delacr.) Theiss. & Syd.
Roumeguere, C. Rev. Mycol. 13: 123-134. 1891. (France).
Theissen, F. and H. Sydow Ann. Mycol., 13: 149-748. 1915.
Saccardo, P. Sulloge Fungorum, 13: 305. 1898. (stems).

Cladosporium herbarum Link
Moskovetz, S. Bull. Jard. Bot. Kieff. 16: 71-87. 1933. (Ukraine).

Phoma chondrillae Hollos
Picbauer, R. Verh. Naturf. Ges. Brünn., 69 (1937): 29-45. 1938. (Czechoslovakia).
Saccardo, P. Syllbge Fungorum, 22: 886-887. 1913. (Hungary - on dead stems).

Phoma herbarum West
Moskovetz, S. Bull. Jard. Kieff. 16: 71-87. 1933. (Ukr.).

Metasphaeria trichostoma (Pass.) Sacc.
Engler u. Prantl Nat. Pfl.-fam. 1: 434. (Italy - stems).
Roumeguere, C. Rev. Mycol. 10: 141-149, 185-193. 1888. (Italy - on dry stems and branches).

Metasphaeria eburnea (Niessl) Sacc.
Engler u. Prantl Nat. Pfl.-fam. 1: 434. (Germany - stems).
Saccardo, P. Sylloge Fungorum, 13: 305. 1898. (stems).

Pyrenopeziza compressula Rehm
Saccardo, P. Sylloge Fungorum 13: 305. 1898. (leaves).

Pyrenophora trichostomella Sacc.
Saccardo, P. Sylloge Fungorum 13: 305. 1898.

Diaporthe orthoceras (Fr.) Nitscke
Saccardo, P. Sylloge Fungorum 13: 305. 1898. (stems).

Phomopsis lactucae forma chondrillae Syd.
Lavitaika, Z.H. Kiev Univ. Naukovi Zapysky, 8(6): 27-45. 1949. (Ukraine).

Annotated Herbarium Specimens of Skeletonweed in Eastern United States, 1874 - 1978

DELAWARE.

Kent Co.: Along roadsides, Smyrna, north end of town. Aug. 13, 1908. Bayard Long & S.S. van Pelt. (ANSP); Smyrna. Aug. 16, 1908. E.B.Bartram. (ANSP).

Sussex Co.: Sandy fields near Milford. Aug. 12, 1897. A.Commons 5. (ANSP, NY); common in sand dunes along Atlantic Ocean at Lewès. Sept. 10, 1974. Reed 96197; July 30, 1957. Reed 38940; Sept. 18, 1971. Reed 91898.

DISTRICT of COLUMBIA.

Washington, D.C. Georgetown, D.C. July 29, 1874. J.J.Carter. (ANSP); Washington. fl. July 13, 1879, rust on leaves, May 10, 1877. Lester F. Ward. (Reed); weed of wasteland, vacont lot in Mt. Pleasant. Sept. 2, 1901. Lyster H. Dewey 522. (NA); Soldiers Home, Washington. Sept. 16, 1896. C.D.Lippincott. (ANSP); Suitland, Washington, roadside. Aug. 22, 1954. F.H.Sargent 6999. (U.Ga - 63065); Terra Cotta, D.C. Aug. 3, 1895. C.L.Pollard 599. (U.Ga.-32700); Washington, D.C. 1888. Jesse H. Holmes. (Ariz).

MARYLAND.

Allegany Co.: Rocky shaley slopes, RR. siding west of Little Orleans. Sept. 7, 1963. Hermann 19346. (US).

MARYLAND.

Anne Arundel Co.: Annapolis Junction along C&O (B&O) RR. July 25, 1974. Reed 95682; along Brock Ridge Road along B&O RR., Annapolis Junction near Howard Co. line. July 30, 1974. Reed 95911.

Baltimore City: Wastes, Baltimore. Miss K.A.Taylor 1622 (Reed), no date, about early 1900's.

Calvert Co.: Cove Point, several sandy acres back from beach. July 14, 1974. Reed 95611; Sept. 10, 1974. Reed 96061; sandy beach along Chesapeake Bay, Cove Point. June 28, 1952. Reed 29303; July 14, 1974. Reed 95891 and 95895.

Charles Co.: Exposed sandy bluff, Rock Point. July 17, 1921. Leonard and Killip 861. (US, rust on stems).

Dorchester Co.: Sandy wastes near Galestown. June 29, 1973. Reed 94467.

Kent Co.: Chestertown. Aug. 7, 1900. E.G.Vanatta. (ANSP).

Montgomery Co.: Yard of Glen Echo School. Sept. 3, 1927. O.M. Freeman. (NA); along B&O RR tracks at Dickerson. Sept. 19, 1974. Reed 96303.

Prince Georges Co.: Laurel. Aug. 29, 1905. C.S.Williamson. (ANSP); roadsides, Rt. US 301 at Rt. US 50, 9 mi. N of Upper Marlboro. July 14, 1974. Reed 95884; along C&O (B&O) RR at Beltsville and Rt. US #1. July 25, 1974. Reed 95656; July 30, 1974. Reed 95920; 1 mi. S of Bladensburg. Aug. 27, 1944. E.C.Leonard 19939. (U.Ga.-34356); along B&O RR tracks at Rt. US #1 near Muirkirk. July 22, 1974. Reed 96390.

Queen Annes Co.: Abandoned farmsted, 0.25 mi N of junction of Rts. 305 and 301, W of Hope. Oct. 1, 1971. J.Massey and H. Massey 3090. (UNC-CH).

Talbot Co.: Sandy soil, Chesapeake Bay Shore near Claiborne. Sept. 8, 1927. Hugh E. Stone. (ANSP); dry pasture, Tilghman Point. Sept. 20, 1943. E.C.Earle 3843. (ANSP); in tall grass, in weedy fields, 3.5 mi. WNW of Longwoods. Sept. 6, 1942. E.C.Earle 3736. (ANSP); edge of fields near Tuckahoe River near Matthews. July 30, 1957. Reed 38924.

Washington Co.: Along B&O RR, 7 mi east of Hancock. Aug. 14, 1955. Reed 36206.

St. Marys Co.: Sandy beaches, Point Lookout State Park. Aug. 3, 1969. Reed 82754.

Wicòmico Co.: Wastes along RR in Salisbury. Aug. 22, 1974. Reed 96374; along RR, at Wilson St at Rt. 13, Salisbury. Aug. 8, 1976. Reed 100902; Salisbury. July 4, 1904. J.J.Carter 280. (ANSP); wastes along RR at Fruitland, Rt. 13, Aug. 22, 1974. Reed 96376; wastes, Sharptown, Rt. 313. June 29, 1973. Reed 94465.

NEW JERSEY.

Atlantic Co.: Sparingly adventive in filled-in land, Vintnor. Sept. 16, 1916. K.K.Mackenzie 7370. (ANSP, NY).

Cape May Co.: Waste ground, Cape May City. Aug. 6, 1917. Witmer Stone. (ANSP); fallow sandy field, E of Cape May C.H. Sept. 11, 1938. Bayard Long 53076. (ANSP, GH); bayside road, Cold Spring. June 13, 1923. O.H.Brown. (ANSP); roadside, Fishing Creek. Sept. 18, 1916. O.H.Brown. (ANSP); Pierces Point, Green Creek. July 14, 1918. O.H.Brown. (ANSP); dry sandy soil at Sea Isle Junction, PRR. July 18, 1931. W.H.Witte. (ANSP); along RR, Wildwood Junction. June 22, 1919. O.H.Brown. (ANSP); common in old fields, Rt. 47 at 12-mile marker, just S of Bidwells Creek. July 31, 1975. Reed 98018; 'Cape May Co.' July 18, 1931. W.H.Wille. (NY).

Cumberland Co.: Roadside wastes, Rt. 548, near Mauricetown. July 31, 1975. Reed 98006; common in fallow fields and sandy wastes Rt. 548 near Mauricetown. July 31, 1975. Reed 98004; wastes in Bridgeton, Rt. 49. July 31, 1975. Reed 98000.

NEW YORK.

Tompkins Co.: Dryden, dry gravelly knoll, SE of Mud Pond. Aug. 13, 1919. K.M.Wiegand, s.n. (GH).

PENNSYLVANIA.

Bedford Co.: Ore mine shale, alt. 1160 ft., $1\frac{1}{4}$ mi. NE of Cessna. Aug. 30, 1941. D. Berkheimer 2933. (ANSP); abandoned fields, alt. 1060 ft., $2\frac{1}{4}$ mi. SE of Five Forks. Aug. 3, 1945. D.Berkheimer 6344. (ANSP); roadsides, alt. 1012 ft., about $1\frac{1}{4}$ mi SSE of Artemas. July 22, 1947. D.Berkheimer 9000 (ANSP); abandoned field, alt. 1000 ft., $1\frac{1}{4}$ mi. NNE of Hewitt. Aug. 13, 1944. D.Berkheimer 5380. (ANSP).

Berks Co.: Old field 1 mi. SE of Albany. Aug. 15, 1952. Schaeffer 41679. (US); Boyertown. Aug. 17, 1913. E.B.Bartram 3360.(ANSP); open field, 1 mi E of Greenswald. Aug. 11, 1952. Schaeffer 41357. (ANSP); fièlds west of Umbrella Hill, 2.25 mi. W of Kutztown. Oct. 9, 1936. C.L.Gruber. (ANSP); Temple near Reading RR tracks. Aug. 13, 1966. W.C.Brumback 5505. (ANSP); weed along RR, Monocacy. Sept. 3, 1951. Hans Wilkens 8327. (ANSP); old field 0.5 mi. NE of Trexler. Aug. 18, 1953. Schaeffer 44931. (ANSP); old field near Moselem. July 30, 1944. Hans Wilkens 7388. (ANSP); 3 mi. NW of Moselem. Sept. 4, 1915. W.H. Leibelsperger 351. (ANSP); upland field 0.8 mi. ENE of Plowville. July 27, 1967. W.C.Brumbach 5901. (ANSP); weedfield, alt. 330 ft., near Pennside. Aug. 23, 1942. D.Berkheimer 3401. (ANSP); dry old field, NE of Pricetown, very abundant locally. Aug. 18, 1935. Hans Wilkens 4173. (ANSP); dry sandy quarry, west of Reiffton. July 27, 1933. W.C.Brumbach 472-33. (ANSP); dry open barren field, 1 mi. NW of Scarlets Mill P.O. Aug. 10, 1941. W.C.Brumbach 3307. (ANSP); dry grassy slope near White Bear Station (Scarlets Mill P.O.). Sept. 3, 1936. Hans Wilkens 4990. (ANSP); thicket on shale hill, Shillington. June 9, 1938. Hans Wilkens 5505. (ANSP).

Franklin Co.: Wooded dry shaley slope, SW of Claylick. Sept. 15, 1961. E.T.Wherry. (ANSP); shale bank along Rt. 274, 3 mi. NE of Doylesburg. Sept. 12, 1955. W.F.Westerfield 18500. (UNC-CH).

Lehigh Co.: Fallow field, 1 mi. NW of Lowhill. Aug. 17, 1950. Schaeffer 34295. (US); aug. 17, 1950. Schaeffer 34297. (ANSP); cinders just W of Walberts. Aug. 29, 1958. Schaeffer 59028. (ANSP, US); fallow field, 1.5 mi. SE of New Smithville. Aug. 13, 1951. Schaeffer (ANSP); 1.25 mi. W of Schnecksville. Aug. 28, 1951. Schaeffer 38046. (ANSP).

Montgomery Co.: Thicket slope, alt. 140 ft., NW of Glasgow. July 30, 1944. D.Berkheimer 5242. (ANSP).

VIRGINIA.

Arlington Co.: Wastes near Alexandria. June 12, 1877. A.S. (ANSP).

Augusta Co.: Along roadside, moist clay soil, junction of Rt. 460 and Rt. 46. Aug. 17, 1971. Craig L. Nessler 365. (Wm. & Mary Coll.).

Campbell Co.: Old RR bed between Lunch Station and Altavista. June 10, 1914. Juliet Faunteleroy 650. (US).

Caroline Co.: Sandy open slope, N of Golansville. Aug. 22, 1938. Fernald & Long 9225. (ANSP).

Clarke Co.: Rocky pasture above Shenandoah River, Trappist Monastery, 6 mi. E of Berryville. Aug. 12, 1951. F.J.Hermann 11722. (NA); limestone fields, Rt. 340 E of Boyce. July 20, 1975. Reed 102511; along N&W RR, Berryville. July 20, 1975. Reed 102509.

Dinwiddie Co.: Cinders of freight yard of N&W RR, spreading, Petersburg. July 21 and 25, 1939. Fernald & Long 10847. (US, ANSP); same locality, June 4, 1940. Fernald & Long 12209. (ANSP).

Fauquier Co.: In open pasture along trail from Overtop to Rattlesnake Mt. June 13, 1937. H.A.Allard 3008. (US).

Henrico Co.: Waste places and on RR ballast, Richmond. July 13, 1940. Fernald and Long 12502. (ANSP).

Northumberland Co.: On side of cultivated field, Rt. 202 at Rt. 619. July 29, 1971. C.L.Nessler & P.L.Busse 226. (Wm. & Mary Coll., UNC-CH).

Madison Co.: Big Meadows, 4 mi. S of Marksville, local in meadow, 1080 m. alt. Aug. 26, 1954. F.R.Fosberg 36029.(US).

Page Co.: Roadsides between Luray and base of Stony Man Mt. Aug. 31, 1913. Ivar Tidestrom 6717. (US, NA).

Prince William Co.: Along RR, common at Rt. US #1, Woodbridge, just south of Occaquan Creek. July 12, 1974. Reed 95560 and 96407; Aug. 9, 1969. Reed 82821; Oct. 19, 1977. (Reed obs.).

Rockingham Co.: On open hillside above Eaton Hollow Overlook, Shenandoah Nat. Park. Aug. 20, 1945. E.H.Walker 3805. (US).

Shenandoah Co.: Shale barrens, E of Mauertown, 3.5 mi S of Signal Knob. Aug. 10, 1941. H.A.Allard 9382. (US); along Southern RR tracks at Strasburg. July 20, 1975. Reed 102510.

Spotsylvania Co.: Fredericksburg. Aug. 20, 1891. Thos. C.Porter. (ANSP); weed along streets of Fredericksburg. Aug. 9, 1969. Reed 82803; also common along railroads in Fredericksburg.

Stafford Co.: Waste ground along Potomac River, at mouth of Aquia Creek, 3 mi SE of Stafford. Aug. 28, 1938. F.J.Hermann 9738. (NA); roadsides, Stafford Co. June 30, 1970. J.Miles Sharpley. (UNC-CH); wastes at Falmouth alongRt. US #1. Aug. 9, 1969. Reed 82805.

Warren Co.: In abandoned drive-in movie lawn, in open sunny dry soil, 0.1 mi. into Front Royal City limits on Rt. 522. Aug. 10, 1971. Craig L. Nessler 491. (Wm. & Mary Coll.) common along N&W RR, Front Royal. Aug. 14, 1975. Reed.

Westmoreland Co.: Dry ground, bay shore, mouth of Currioman Creek. Aug. 20, 1952. F.H.Sargent. (U.Ga.-47138); Kinsdale. Aug. 10, 1904. Ivar Tidestrom E-6962. (U.Ga.-18779).

WEST VIRGINIA.

Berkeley Co.: Along fencerows and in pastures, Imwood. Aug. 16, 1947. H.N.Moldenke 19174. (ANSP).

Grant Co.: Several acres over shale barrens and old fields, 1-2 mi. S of Petersburg, Rt. 220. Sept. 20, 1974. Reed 95968. (Rust).

Hardy Co.: Shale slopes, several hundred acres, along Baker Rock Road, off Rt. 220, 5-7 mi. S of Moorefield. Sept. 20, 1974. Reed 96186; shale ledges, just E of Durgon. Sept. 20, 1974. Reed 96137 (Rust).

GEORGIA.

Hall Co.: Piedmont Prov., along RR, leafy up to top of plant. July 12, 1955. W.P.Adams et al. 19106. (U.Ga.).

MICHIGAN.

Kalamazoo Co.: Vicksburg. Sept. 18, 1936. C.R.Hanes 3506. (NY); 1 mi. N of Comstock. Sept. 3, 1936. C.R.Hanes 3636. (GH).

GENERAL BIBLIOGRAPHY

Bubak, Fr. About a few Puccinia on composites. Oesterr. Bot. Zeitschr. 52: 92-96. 1902.

Caresche, L.A. and A.J. Wapshere The Chondrilla gall midge, Cystiphora schmidti (Rubsamen). (Diptera, Cecidiomyiidae). II. Biology and Host Specificity. (Biological control of Chondrilla juncea). Bull. Entomol. Res. 65: 55-64. 1975.

Caresche, A.J. and S. Hasan The ecology of Chondrilla (an important weed of wheat crops) in the eastern Mediterranean. Journ. Appl. Ecol. 13: 545-553. 1976.

Carter, M.V. Epidemiology of fungal pathogens: Puccinia chondrillina. Adelaide Univ. Waite Agric. Res. Inst., Bien. Rept. 1970/71: 77. 1972.

Catt, M.J. Biological control of skeletonweed. S. Austral. Journ. Agric. 76: 22-25, illus. 1973.

Cullen, J.M. Seasonal and regional variation in the success of organisms imported to combat skeletonweed, Chondrilla juncea, in Australia. Misc. Publ. Commonwealth. Inst. Biol. Control, 8: 111-117. 1974.

Cullen, J.M., P.F.Kable and M. Catt Edpidemic spread of a rust imported for biological control. Nature 244(5416): 462-464. 1972. (Puccinia chondrillina).

Cuthbertson, E.G. Regeneration of skeletonweed (Chondrilla juncea) from root fragments. Australian Weed Res.Newsletter, 1962(1): 10-11. 1962.

---- Skeleton Weed, distribution and control. Agric. Res. Inst. Wagga Wagga, N.S.W. Dept. Agric. Bull. 68: 1-48, illus. 1967.

---- Chondrilla juncea in Australia, III. Seed maturity and other factors affecting germination and establishment. Austral. Journ. Exp. Agric. Anim. Husb., 10(42): 63-66. 1970.

---- Chondrilla juncea in Australia, IV. Root morphology and regenration from root fragments. Aystral. Journ. Exp. Agric. Anim. Husb., 12(58): 528-534, illus. 1972.

Dale, M.B., R.H.Groves, V.J.Hull and J.F. O'Callaghan A new method for describing leaf shape. (Chondrilla juncea). New Phytol. 70(2): 437-442, illus. 1971.

Greenham, C.G., V.G.Hull and M.M.Ward Electrical characteristics as discriminant criteria for three forms of skeletonweed (Chandrilla juncea). Journ. Exp. Bot., 23(74): 210-215. 1972.

Groves, R.H. and V.J.Hull Variation in density and cover of Chondrilla juncea L. in southeastern Australia. CSIRO (Commonw. Sci. Ind. Res. Organ.), Field Sta. Rec. 9(2): 57-71. 1970.

Groves, R.H. and J.D.Williams Growth of skeleton weed (Chondrilla juncea L.) as affected by growth of subterranean clover (Trifolium subterranea L.), and infection by Puccinia chondrillina Bubak & Sydow. Austral. Journ. Agric. Res. 26: 975-983. 1975.

Hasan, P. Recent advances in the use of plant pathogens (fungi) as biocontrol agents of weeds (Chondrilla juncea). PANS, Pest Artic. News Summ. 20(4): 437-443. 1974.

Hasan, S. Specificity and host specialization of Puccinia chondrillina. Ann. Appl. Biol. 72: 257-263. 1972.

---- First introduction of a rust fungus in Australia for biological control of skeletonweed. Phytopathology, 64(2): 253-254. 1974.

----, J. Giannatti and C. Vago Virus-like particles associated with a disease of Chondrilla juncea. Phytopathology, 63(6): 791-793. 1973.

---- and P.T.Jenkins The effect of some climatic factors on infectivity of the skeletonweed rust, Puccinia chondrillina. Plant Dis. Rep., 56: 858-860, illus. 1972.

---- and A.J.Wapshere The biology of Puccinia chondrillina, a potential biological control agent of skeletonweed. Ann. Appl. Biol. 74(3): 325-332. 1973.

Kefford, N.D. Organ regeneration on excised roots of Chondrilla juncea, and its chemical regulation. Plant Physiol., 46(Suppl.): 10. 1970.

McClelland, V.F. and G.J.Wells Lucerne tame skeletonweed in the Mallee. (Chondrilla juncea). Journ. Dept. Agric. Victoria, 66(7): 244-246. 1968.

McVean, D.N. Skeleton Weed in Australia. New Scient. 27: 764-766, 3 figs. 1965. (Origin, distribution and biology in Australia).

---- Ecology of Chondrilla juncea L. in southeastern Australia. Journ. Ecol., 54(2): 345-365. 1966. (An apomictic composite of Eurasian steppe origin; appearing in SE Australia in 1917; now occupying most of the wheat belt of the continent).

Meadley, G.R.W. Skeleton Weed. Journ. Agric. W. Auatralia, Bull. 3167, Ser. IV, 4(11): 2-7, illus. 1963.

---- The recent story of Skeletonweed - a menace to our wheat industry. Journ. Agric. W. Australia, Bull. 3413, Ser. IV, 7(3): 3-6. 1966.

Molnar, V. Picloram -- a summary of its place in controlling skeleton weed (Chondrilla juncea). Journ. Dept. Agric. Victoria, 64(12): 533-535. 1966.

Morschel, J.R. Biological control agents for skeleton weed.

FAO, Pl. Protect. Commit. S.E. Asia and Pacific Region, Quart. Newsletter, 15(2): 23. 1972.

New South Wales, Dept. Agric. Reports. Weeds (Nassella trichotoma, Baccharis halimifolia, Chondrilla juncea). Report 1963-64: 1-140. 1965.

Russell, K.O. Weed control in Australia wheat, crops with tribunil -- Chondrilla juncea herbicide. Pflanzenschulz-Nachr. Bayer., 23(1): 58-66. 1970.

Steele, B. Weeds threaten sheep country (N.S.W., Australia). PANS (C), 13(2): 122. 1967. (Chondrilla juncea).

Wapshere, A.J. The biological control of Chondrilla juncea L. (Skeletonweed): a preliminary understanding. 13th Internat. Congr. Entomol., Moscow, Proc. 2: 200-201. 1968.

---- The biological control of Chondrilla juncea - D, an ecological approach. Journ. Ecol., 57(3): 22-24. 1969. (Aceria chondrillae, Puccinia chondrillina).

---- Host specificity of phytophagous organisms and the evolutionary centers of plant genera or sub-genera. (Chondrilla juncea). Entomophaga, 19(3): 301-309. 1974.

Waterhouse, D.F. The entomological control of weeds in Australia. Symp. 11th Pacific Sci. Congr., Tokyo. 1966: 28 (Natural Enemies in the Pacific Area, Biological Control); in Mushi, 39 (Suppl.): 109-118. 1967. (Chondrilla juncea).

Wells, G.J. Research into skeletonweed control in the Mallee. Journ. Agric. Victoria, 65(7): 277-283, 320-322. 1967.

---- Skeleton Weed (Chondrilla juncea) in the Victorian Mallee, I. Competetion with legumes. Austral. Journ. Exp. Agric. Anim. Husb., 9(40): 521-527, illus. 1969.

---- Skeleton Weed (Chondrilla juncea) in the Victorian Mallee, II. Effect of legumes on soil fertility, subsequent wheat crop and weed population. Austral. Journ. Exp. Afric. Anim. Husb., 10(46): 622-629. 1970.

---- Skeleton Weed (Chondrilla juncea) in the Victorian Mallee, III. The effects of applied phosphorus and nitrogen on wheat on infested land. Austral. Journ. Exp. Agric. Anim. Husb., 11(49): 229-235, illus. 1971.

---- Skeleton Weed (Chondrilla juncea) in the Victorian Mallee, IV. Effects of fallowing on wheat yields and weed populations. Austral. Journ. Exp. Agric. Anim. Husb., 11(50): 313-319.1971.

---- Skeleton Weed (Chondrilla juncea) in the Victorian Mallee, V. Chemical fallowing. Austral. Journ. Exp. Agric. Anim. Husb., 11(50): 320-327, illus. 1971.