THE BIOLOGY OF CANADIAN WEEDS. 42.
Stellaria media (L.) Vill.

ROY TURKINGTON, NORMAN C. KENKEL, and GAIL D. FRANKO

Department of Botany, University of British Columbia, Vancouver, British Columbia V6T 2B1. *Received 7 Jan. 1980, accepted 20 Mar. 1980.*

TURKINGTON, ROY, KENKEL, NORMAN C. AND FRANKO, GAIL D. 1980. The biology of Canadian weeds. 42. *Stellaria media* (L.) Vill. Can. J. Plant Sci. **60**: 981–992.

This paper provides a summary of biological data on *Stellaria media* (L.) Vill., commonly known as chickweed. It is found throughout most of the world and is present in all Canadian provinces and both territories, being particularly abundant in British Columbia and eastern Canada. Chickweed is a weed of grain fields, young pastures, lawns, and gardens, and can be controlled by the use of several common herbicides.

La Stellaire moyenne, aussi connue sous le nom de Mouron des oiseaux (*Stellaria media* L.), se rencontre dans presque toutes les parties du monde et elle a colonisé toutes les provinces et les deux Territoires du Canada. Elle est particulièrement abondante en Colombie-Britannique et dans l'est du Canada. La stellaire est une mauvaise herbe des céréales, des jeunes pâtures, des pelouses et des jardins. On dispose contre elle de plusieurs bons herbicides.

1. Names

Stellaria media (L.) Vill. — **chickweed** (Canada Weed Committee 1975), **stellaire moyenne** (Ferron and Cayouette 1975), **mouron des oiseaux** (Conners 1967). Caryophyllaceae, pink family, Caryophyllacées.

The species is occasionally referred to as *Alsine media* L. (Löve and Löve 1975). The authority for the name *Stellaria media* is often cited as "(L.) Cyrillo" rather than "(L.) Vill" (Hitchcock and Cronquist 1973; Hultén 1970; Taylor and MacBryde 1977). This is an error in the attribution of the authority for the transfer of the epithet *media* from *Alsine* to *Stellaria* (Burnat 1892).

2. Description and Account of Variation

(a) *S. media* is an annual or winter annual with a slender tap root; diffusely branched stems, either decumbent or ascending (Fig. 1), 5–40 cm, round in cross section with a single line of hairs down each internode; leaves opposite, broadly oval and pointed, entire, glabrous; lower leaves 3–20 mm, stalked, the petiole with a single line of hairs; upper leaves to 25 mm, sessile; flowers solitary in the leaf axils, or from few to many and borne in axillary or terminal cymes, star-shaped (hence *Stellaria*) (Fig. 2B), 5 mm in diameter on short peduncles; sepals 5, separate, hairy, 4.5–5 mm; petals 5, white, deeply bifid, shorter than sepals; styles 3; stamens 3–10; anthers red-violet; capsules longer than sepals, opening by 6 teeth to release an average of 8–10 seeds; seeds (Fig. 2A, C, D) 0.9–1.3 mm across, yellowish to dark brown, flattened, almost circular, sometimes narrowed to base, with 5–6 rows of low protuberances, maturing rapidly; flowers produced throughout the growing season.

A chromosome number of $2n$ = 20 II has been reported from the Queen Charlotte Islands (Taylor and Mulligan 1968) and from Ontario (Mulligan 1961). Mulligan (pers. comm.) has unpublished counts of *S.*

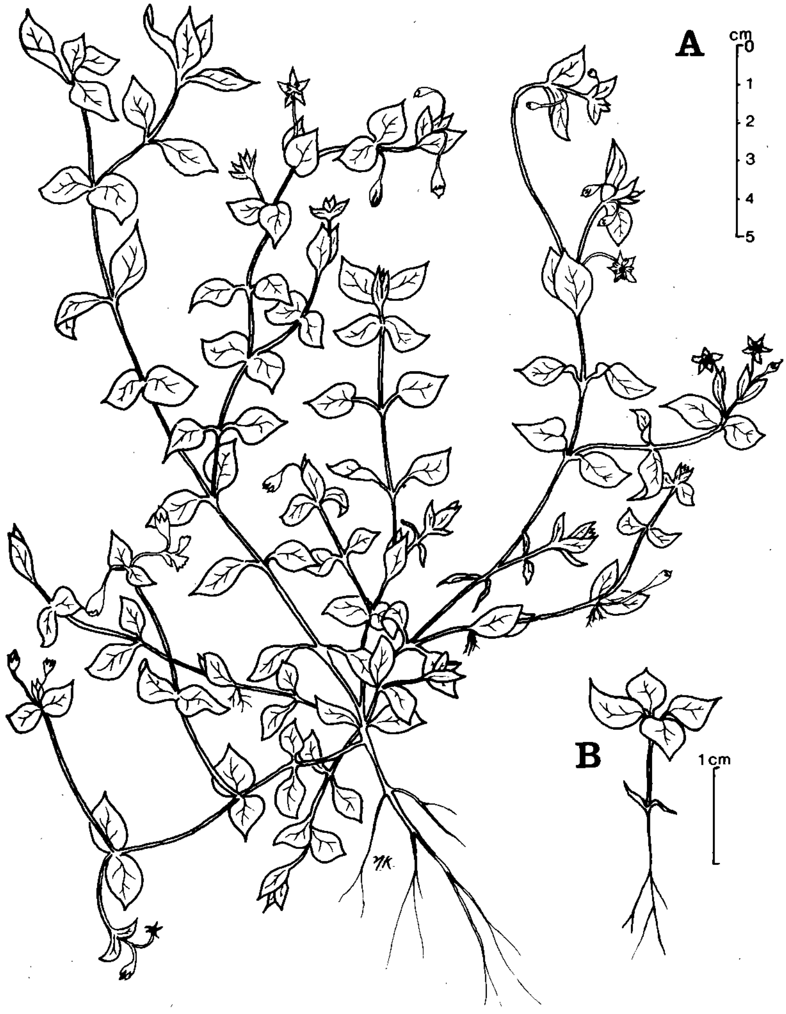

Fig. 1. *Stellaria media* (L.) Vill. (A) 5-wk-old adult plant and (B) 10-day-old seedling.

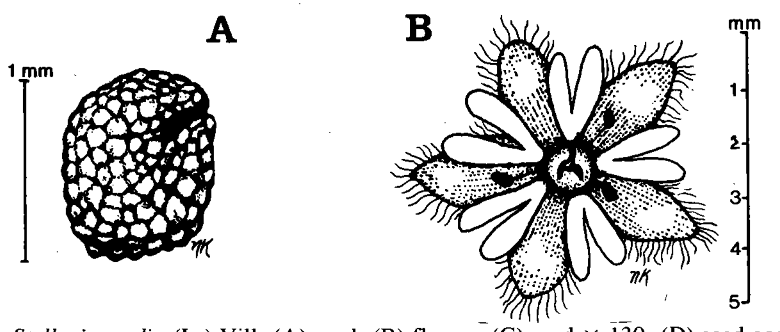

Fig. 2. *Stellaria media* (L.) Vill. (A) seed, (B) flower, (C) seed × 130, (D) seed coat × 544.

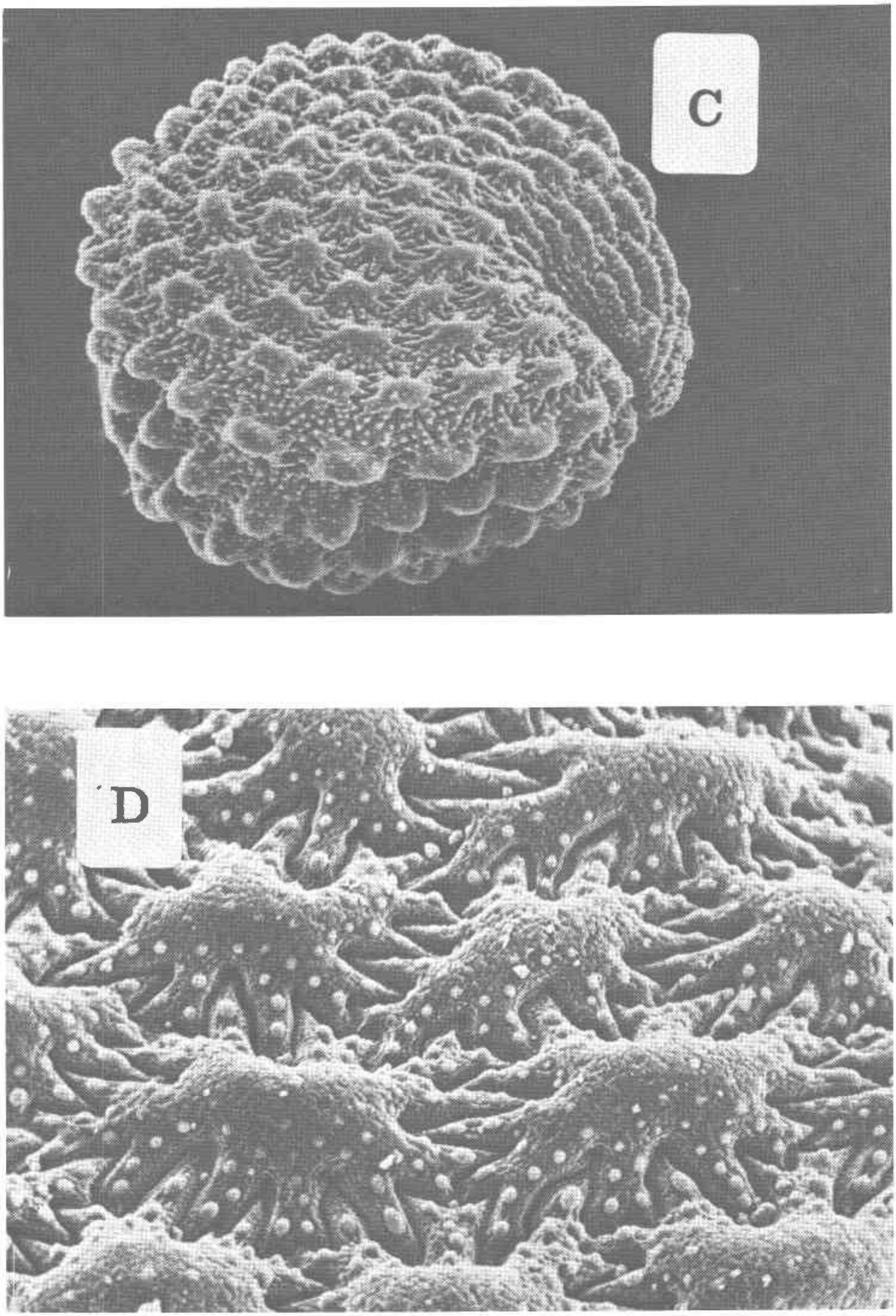

Fig. 2. *Stellaria media* (L.) Vill. (C) and (D) taken with scanning electron microscope.

media from four locations in Ottawa; all formed 20 bivalents at metaphase I of meiosis. Counts of $2n$ = 28, 36, 40, 42 and 44 have been reported from Eurasia with $2n$ = 40 predominating (Federov 1974; Löve and Löve 1975; Moore 1973).

(b) *Stellaria media* is similar to *Cerastium fontanum*, *C. arvense* and *S. graminea*, but it differs from all these in its distinctive pattern of pubescence, i.e. a single line of hairs down the stems and petioles.

(c) *S. media* expresses a high degree of phenotypic plasticity and genotypic flexibility (Sinha and Whitehead 1965), varying in size, habit, hairiness, length of petals, number of stamens, and number, size, and surface details of seeds.

Using such characteristics as calyx and corolla length, number of stamens, and the shape of petals, Béguinot (1921, cited in Matzke 1932) described 32 varieties of *S. media*.

Kraft (1917) observed a reduction in the number and size of petals in plants of both poor and very rich soils.

Matzke (1932) observed that flowers with from 2 to 10 stamens may occur on the same plant. Reinöhl (1903) reported that light and moisture determine the number of stamens in chickweed, but there has been no subsequent evidence to support this finding.

Peterson's (1936) transplant study showed clear ecotypic differentiation into arctic/subarctic populations and Mediterranean populations. Germination is delayed in the former with subsequent rapid development and sparse vegetative growth. The latter germinate almost immediately, develop over a longer growing season and have luxuriant vegetative growth. Peterson (1936) also distinguished between maritime (rapid germination) and continental forms (delay before germination).

(d) Figures 1 and 2 show the main diagnostic features of a flower, seed, seedling, and 5-wk-old plant of *S. media*.

3. Economic Importance

(a) Detrimental — In Canada, *S. media* is a weed of grain fields and other cultivated areas and pastures. It can be a major contaminant among some crops; e.g. on Westham Island in the Fraser Delta, it has > 15% cover among raspberry and strawberry crops, and from 80 to 100% cover in barley and potato crops. Comparable data are not available for elsewhere in Canada. *S. media* competes with crop plants by shading and smothering young seedlings with its mat-like growth (Fryer and Makepeace 1977). Mann and Barnes (1950) reported a 66–80% loss in a barley crop due to chickweed competition for root space. Barley and chickweed roots grow at the same level but the chickweed roots grow faster. When grown together the weed can absorb nitrogen more readily than barley. In England, O'Leary (1973) surveyed 5300 fields of spring and winter cereals and found chickweed to be the most abundant weed. *S. media* seeds are contaminants in seeds of wheat, barley, rye, oats, timothy, rape, swede, mustard, fodder beets, sugar beets and kale (Fryer and Makepeace 1977).

S. media is capable of accumulating nitrates to potentially toxic levels (Case 1957), and grazing of the weed may cause digestive disorders in sheep and goats (Carruthers 1903). It harbors viruses and fungi which overwinter between crop plantings (Converse and Stace-Smith 1971), as well as aphids and nematodes which transmit viruses to crop plants (Fryer and Evans 1968). In some cases, viruses may be transmitted via the seeds of *S. media* (Provvidenti 1975).

(b) Beneficial — Chickweed "can prevent soil erosion, preserve soil structure and regulate fertility" (Fryer and Makepeace 1977). It is a source of food for animals, the plant being eaten by hogs and rabbits (Spencer 1940) and the seeds by birds (Hatfield 1970). Man sometimes uses the plant for salads (Grieve 1959).

In Switzerland, chickweed is used in weed control! Infestations of *Convolvulus arvensis* and *C. sepium* in vineyards are suppressed by chickweed. The chickweed itself is not a problem (Stalder et al. 1973).

(c) Legislation — *S. media* is listed as a noxious weed in the Noxious Weeds Act of Alberta and Manitoba. It is named in the Canada Seeds Act and Regulations (Anonymous 1967), where the percentage of the weed seed affects the grade of grass mixtures.

4. Geographical Distribution

The distribution of *S. media* in Canada and adjacent Alaska is shown in Fig. 3. It is found from Vancouver Island to Newfoundland, and from the United States border to the MacKenzie delta at 69°N. It is more common in B.C. and eastern Canada than in the prairies (Groh and Frankton 1946, 1948).

It is found widely on every continent, from Spitzbergen at 79°N (Hultén 1970) to the Subantarctic islands at 60°S (Walton 1975). While it is generally absent only from the most arctic regions and very dry areas, it is common in the tropics only at high elevations, e.g. 1300 m in Kenya.

5. Habit

(a) Climatic requirements — Chickweed generally prefers cool temperatures; Walkey and Cooper (1976) reported an optimum of 22°C for laboratory populations. However, it can obviously tolerate cold conditions since its range extends into the Arctic and Subantarctic regions. It does best in moist regions, persisting and even flowering throughout the winter in cool, moist climates such as in southwestern B.C. (Kenkel, unpublished). But it will not flower during winter months if the temperature remains below 2°C (Moss 1914). It cannot tolerate

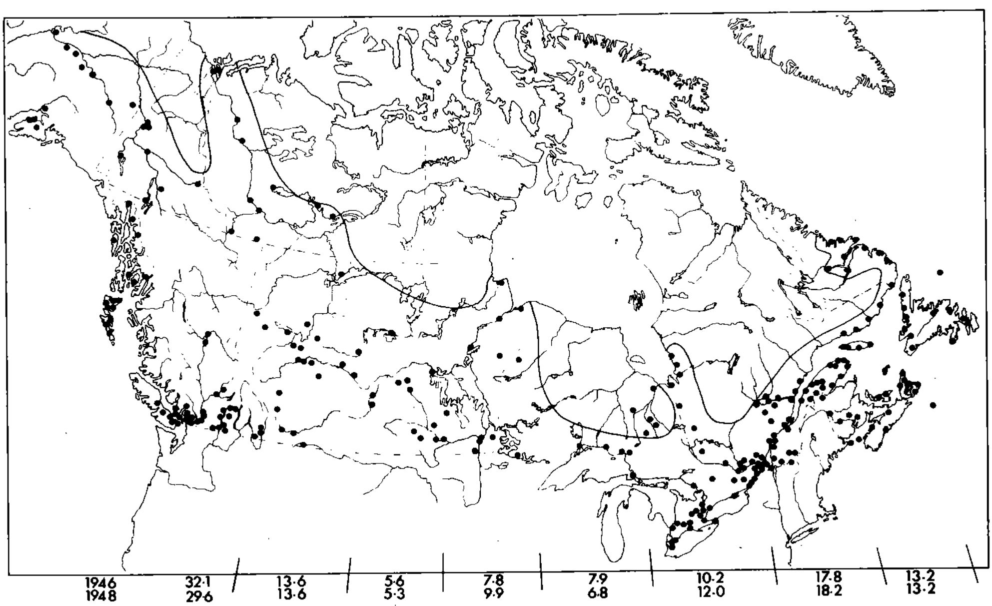

Fig. 3. The distribution of *Stellaria media* (L.) Vill. in Canada and part of Alaska from specimens in the herbaria of the Biosystematics Research Institute, Ottawa, University of Saskatchewan, University of Alberta, and University of British Columbia. The solid line represents the northern limit of distribution as shown by Hultén (1970). Note that a few specimens have since been collected north of Hultén's line. The values below the map represent the frequency of the species as recorded in longitudinal belts by two Canadian Weed Surveys (Groh and Frankton 1946, 1948).

dry conditions, and during hot, dry summers will die back (Roberts and Dawkins 1967).

Chickweed prefers partially shady conditions such as found near buildings (King 1966) and under the cover of row crops. It is often found growing in gullies, track marks, etc. which provide a suitable microclimate of moisture, humidity and shelter.

(b) Substratum — Chickweed grows on most types of soil (Salisbury 1974) but does best on moist, heavy (King 1966), high nitrogen soils (Roberts 1962) such as found in chicken coops and cow barns (King 1966) and on the guano rocks of the Scilly Isles (Lousley 1971). It prefers a pH of 5.2–8.2 (Lefevre 1956) but has been found on soils with a pH of 4.8. At these levels growth is reduced, often due to aluminum toxicity (Buchanan et al. 1975). Aluminum concentrations greater than 2 ppm cause toxicity symptoms (Gilbert and Pember 1935).

(c) Communities in which the species occur — *S. media* grows in young or disturbed communities such as cultivated areas, young pastures, gardens, lawns and waste places. Some of the crops with which it grows are listed in Section 3a. The only data on weedy associates in Canada are from the Fraser Delta. There, *S. media* grows with *Matricaria matricarioides* (Less.) Porter, *Polygonum lapathifolium* L., *Senecio vulgaris* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Capsella bursa-pastoris* (L.) Medic., *Agropyron repens* (L.) Beauv. and *Poa annua* L.

6. History

Stellaria media is native to Europe and seeds of the species have been found in preglacial and mesolithic deposits in Britain (Salisbury 1964). It is believed to have been in Greenland from the 1400's to 1721, before the period of European settlement (Pedersen 1972). How or when the species was introduced to N. America is not known, but in 1672, Josselyn (cited by Rousseau 1968) recorded the species in New England. It was common when collected by Holmes in Montreal in 1821, and Cochran identified it in Nova Scotia in 1829. St. Cyr collected it on the Isle d'Anticosti in 1882 (Rousseau 1968) and it was listed as a farm weed in Canada by Clark and Fletcher (1909).

7. Growth and Development

(a) Morphology — "The ability of *Stellaria media* to have achieved such success . . . can only be attributed to the remarkable intrinsic variability which is attested in so many features . . . (and) . . . is paralleled by a physiological variability" (Salisbury 1964).

Like most weedy annuals, *S. media* has numerous, small, easily dispersed seeds and it has the additional advantage of being able to flower and set seed throughout the year. Dry weight distribution studies (Turkington, unpublished) show that chickweed allocates only 6% of its total dry weight to roots while channeling 76% into stem and leaves, an advantageous strategy for colonizing.

Under suitable conditions — partial shade, rich, damp, disturbed soil — the stems of *S. media* will root at the nodes (Frankton and Mulligan 1970). This is an advantageous characteristic to the species in newly disturbed habitats.

(b) Perennation — Chickweed is able to grow at 2°C when most plants cannot (King 1966). In colder environments it overwinters as seed; in mild climates, it is a winter annual, being able to overwinter after fall germination. This has been reported from England (Heathcote and Byford 1975) and has been observed in southwestern B.C. (Kenkel, unpublished). Peterson (1936) describes ecotypes that are adapted to cold winter temperatures.

(c) Physiology — Individual plants living through the winter show a shift in storage physiology from summer starch to winter sugar. High concentrations of sugar sap in winter ensure a high osmotic value in cells,

preventing ice crystal formation (Salisbury 1974).

(d) Phenology — Chickweed is a day-neutral species (Fryer and Makepeace 1977). Under suitable conditions, flowering takes place throughout the year as does maturation and shedding of seed. During the winter, flowers tend to be without petals, and are self-fertilized (King 1966). Although seeds will germinate at any time of the year under suitable conditions, most germinate and establish in early spring and late fall (Roberts and Dawkins 1967).

Caspers (1977) followed the seasonal changes of caloric values and ash content of the aboveground portion of chickweed. Generally, caloric values are highest in February and lowest between August and October. Ash contents are highest in October and lowest in February.

(e) Mycorrhiza — No mycorrhizal associations have been reported.

8. Reproduction

(a) Floral biology — *S. media* is cleistogamous and almost homogamous (Salisbury 1974), self-pollinated (Mulligan and Kevan 1973) and self-fertilized (Mulligan and Findlay 1970). Mulligan and Kevan (1973) reported that no insects visited the flowers in their studies, an expected result in cleistogamy; but in European studies, Proctor and Yeo (1973) reported visits by ichneumon wasps, and Knuth (1908) recorded visits by members of the Diptera, Hymenoptera and Thysanoptera. Gilkey (1957) reported that bees are attracted by the flower fragrance.

(b) Seed production and dispersal — The mean weight of 1000 chickweed seeds has been reported as 0.362 g (Whitehead and Sinha 1967) and 0.505 g (King 1966). The number of seeds per fruit ranges from 1 to 20 (Salisbury 1964) although 10 is average. Franko (unpublished) counted an average of 9 seeds per fruit with a top value of 18 in a study at the University of British Columbia. The numbers of seeds per plant range from 500 (Long 1938) to 2500 (Salisbury 1964), and the number of seeds per hectare ranges from 5.1 million to 15 million (Long 1938; Roberts and Dawkins 1967).

Seeds are dispersed in a number of ways: by footwear, through the digestive tracts of birds, cattle, horses and pigs (Salisbury 1964), by ants (King 1966) and by wind (Grieve 1959). The seed is also dispersed as a contaminant in pasture mixtures or seeds of other crops.

(c) Viability of seeds and germination — Shed seeds of chickweed have 90–100% viability. Champness and Morris (1948) found that seed viability is highest in acid, waterlogged soils. A high proportion of total emergence occurs within the first few months after dispersal (except in dry summers (Roberts 1964). Fryer and Makepeace (1977) found 95% germination, and Toole and Brown (1946) found 97% viability 1 yr after shedding. Roberts (1964) dry-stored seeds for several months, then planted them, and after 3 yr found that 70.6% emerged, 5% were dormant and 24.4% were not accounted for. Toole and Brown (1946) reported 22% viability after 10 yr and Fryer and Makepeace (1977) claimed that a proportion of seeds will survive more than 60 yr when deeply buried under grass. Seeds subject to severe oxygen starvation (partial pressure $O_2 < 8$) will remain in a dormant condition (Mullverstedt 1963).

Although many of the results regarding germination are conflicting, certain general features are evident. The optimum constant temperature for germination is between 12°C and 20°C, and while germination can take place at 2°C or even less, a cold treatment will often induce a light requirement. High temperatures are inhibitory and germination does not occur when the temperature exceeds 30°C. Daily alternations of temperature enhance germination. Germination of freshly harvested seeds does not seem to be promoted by light, and strong illumination may inhibit it. After-ripening occurs both in dry and in moist storage, but seeds that have been buried for some time in soil require exposure to light before germination can take place (Roberts and Lockett 1975). Baskin and Baskin (1976, 1979) found that high temperatures promote after-ripening and that a green "safe" light used with dark controls was sufficient to stimulate germination. However, the wavelength responsible for this stimulation may have been blue (400–500 nm) or yellow-orange (550–600 nm) rather than the green (500–550 nm) per se. For emergence, the optimal depth of burial is 1.0 cm and the maximum depth is 2.0 cm (King 1966).

(d) Vegetative reproduction — Under suitable conditions, chickweed will root at the nodes of prostrate stems (Frankton and Mulligan 1970).

9. Hybrids

Stace (1975) reported a hybrid between *S. media* and *S. neglecta* in Britain, but this has yet to be verified. Whitehead and Sinha (1967) pointed out that the incidence of crosses within different entities in the *Stellaria media* complex has lead to taxonomic problems.

Peterson (1933, 1936) reported artificial intra- and interspecific crosses within the *Stellaria media* complex. The intraspecific crosses had a very low rate of fertility. In most cases, interspecific crosses yielded no F_1. However, *S. media* ($2n=42$) × *S. neglecta* yielded sterile F_1 and *S. media* ($2n=42$) × *S. neglecta* var. *grandiflora* ($2n=44$) yielded an F_1 with $2n=43$ (fertility of 64%).

10. Population Dynamics

The flowers of *S. media* are ephemeral and open only for 1 day (Salisbury 1974), during daylight hours in bright weather (Grieve 1959). It flowers and sets seed throughout the year with two main flushes of germination, early spring and late fall. It grows most rapidly just after germination but dies back as dry, hot summers or cold winters set in. The mean life span is 5–7 wk with 4–5 of this being required to reach flowering (Sinha and Whitehead 1965). There are usually one or two generations per year but sometimes three (Salisbury 1964). Population density may be quite high and a count of 668 chickweed plants/m^2 was recorded in an area between potato and barley crops on Westham Island in the Fraser Delta.

Chickweed is a pioneering species and grows most rapidly in open areas. It is quick to colonize bare patches in fields and can grow at lower temperatures than most grasses (Naber and Luten 1972). It is, however, a poor competitor (Lawson 1972) and is soon out-competed in growing swards, although it is persistent in grazed pastures (Schulz 1970). Chickweed may, however, be a successful competitor when its mat-like growth form smothers the seedlings of other species.

Chickweed often exists as a solitary plant which may spread up to 1.5 m, or as small patches in gardens. But, under suitable conditions it may form a continuous expanse e.g. 80–100% cover in a 2-ha barley field on Westham Island, B.C. (Franko, unpublished).

11. Response to Herbicides and Other Chemicals

The following information has been synthesized from information produced by the Canada Weed Committee (1977), the weed control series of the B.C. Ministry of Agriculture (Anonymous 1977), and the Ontario Herbicide Committee (1978).

Stellaria media is resistant to foliar applications of 2,4-DB or MCPB, Bromoxynil + MCPA (1:1) and Dichlorprop + 2,4-D (1:1). It is somewhat resistant to 2,4-D, 2,4,5-T and MCPA. The weed is controlled by Fenoprop (1.2 kg/ha), Mecoprop (1.2 kg/ha), Dicamba (0.42 kg/ha), Dicamba + Phenoxy (1:3 at 0.56 kg/ha), Linuron + MCPA (1:2 at 0.84 kg/ha), Pronadime (0.84 kg/ha) and Chloroxuron (5.6 kg/ha).

12. Response to Other Human Manipulations

Close mowing controls chickweed (Muenscher 1955) and the population of viable seeds in the soil is greatly reduced after the second year of vegetable cropping (Roberts 1962). Roberts and Dawkins (1967) reported a 56% decrease in numbers of chickweed seeds in areas ploughed four times per year, compared to a 30% decrease in undisturbed plots. A June ploughing will cause a 100% increase in the number of summer seedlings.

Good drainage is an effective control measure (Clark and Fletcher 1909).

S. media is an effective competitor against cabbage seedlings, but an early spring weeding allows the cabbage to become established before the weed reestablishes (Lawson 1972). Like most weeds, chickweed is favored by manuring (Roberts 1962) and by grazing when grown with grass (Schulz 1970).

13. Response to Parasites

Table 1 lists the parasites which are associated with *S. media* in Canada and adjacent parts of the U.S.A. In all cases the mature plant is attacked. In other localities, Tomlinson and Walker (1973) found tht cucumber mosaic virus affects chickweed, giving the leaves a mottled appearance; but viral infections are often symptomless in chickweed (Converse and Stace-Smith 1971). Viral transmission is via pollen (Tomlinson and Carter 1970) or via seed (Provvidenti 1975). The virus can also be transmitted by aphids from the chickweed to the crop plant (Provvidenti 1975).

Adam and Todd (1974) reported that chickweed is a host for the potato rot fungus (*Phoma exigua* var. *foveata*) and can transmit the fungus to a potato crop.

Viruses, fungi, aphids, and nematodes often overwinter on chickweed plants and

Table 1. Some of the parasites known to be associated with *Stellaria media* in Canada and adjacent parts of the U.S.A.

Viruses		
White clover mosaic virus	British Columbia	Conners 1967
Clover yellow mosaic virus	British Columbia	Toms 1964
Cucumber mosaic virus	New York	Provvidenti 1975
Tomato ring spot virus	Vancouver, Washington	Converse & Stace-Smith 1971
Turnip mosaic virus	New Jersey	Citir & Varney 1974
Beet curly-top virus	Oregon	Smith 1972
Beet western yellows virus	Oregon	Smith 1972
Beet yellows virus	All countries growing beets	Smith 1972
Carnation mottle virus	Wide range	Smith 1972
Raspberry ring spot virus	Wide range	Smith 1972
Tomato black-ring virus	Wide range	Smith 1972
Fungi		
Septoria stellariae Ro. & Desm.	British Columbia	Conners 1967, Toms 1964
Melampsorella caryophyllacearum Schroet.	B.C. and Ontario	Conners 1967, Toms 1964
Puccinia arenariae (Schum.) Wint.	Prince Edward Island	Conners 1967
Insecta		
Myzus ascalonicus	Canada	Richards 1976
Myzus caryophyllacearum	Canada	Richards 1976
Myzus persicae (Sulzer)	New York	Provvidenti 1975

are capable of infecting the crop plants sown the following season (Converse and Stace-Smith 1971).

Cooper and Harrison (1973) found that tobacco rattle virus infection in a potato field was dependent upon host preference of the vector nematodes (*Trichodorus* sp.). Increased weeding of *S. media* served only to increase the incidence of the virus on the potato. The authors concluded that the vector nematode prefers chickweed as a host, but will feed alternatively on the potato crop when the chickweed is not available.

ACKNOWLEDGMENTS

The authors are grateful for financial assistance from the National Reasearch Council of Canada and the YEPU program at the University of British Columbia. We also express our gratitude to herbaria personnel at Agriculture Canada, Ottawa (W. J. Cody and assistants), the University of Saskatchewan, Saskatoon (V. Harms), the University of Alberta, Edmonton (J. Packer), and the University of British Columbia, Vancouver (J. Pinder-Moss) who supplied much of the information on which Fig. 3 is based. We are also grateful to Dr. J. McNeil of the Biosystematics Research Inst., Ottawa, Ontario for valuable assistance concerning the authority to be ascribed to *Stellaria media* and to Leszlo Veto for taking the excellent S.E.M. photographs. Finally, we wish to thank Dr. J. Maze for valuable comments on the manuscript.

ADAM, J. W. and TODD, J. M. 1974. Observations on the relative occurrences of *Phoma exigua* var. *foveata* on weed hosts and potatoes. Potato Res. **17**: 347–350.

ANONYMOUS. 1967. Seeds Act and Regulations. Agric. Canada. Queen's Printer, Ottawa, Ont. 50 pp.

ANONYMOUS. 1977. Field crop facts. Weed control series. 2. Chickweed. British Columbia Min. of Agric. 3 pp.

BASKIN, J. M. and BASKIN, C. C. 1976. High temperature requirement for after-ripening in seeds of winter annuals. New Phytol. **77**: 619–624.

BASKIN, J. M. and BASKIN, C. C. 1979. Promotion of germination of *Stellaria media* seeds by light from a green safe lamp. New Phytol. **82**: 381–383.

BUCHANAN, G. A., HOVELAND, C. S. and HARRIS, M. C. 1975. Response of weeds to soil pH. Weed Sci. **23**: 473–477.

BURNAT. 1892. Flore des alpes maritimes, Vol. 1. Genève & Bale, Lyon. 302 pp.

CANADA WEED COMMITTEE. 1975. Common and botanical names of weeds in Canada. Can. Dep. Agric. Publ. 1937. Ottawa, Ont. 67 pp.

CANADA WEED COMMITTEE. 1977. Report of the Research Appraisal and Research Planning Committee, Western Section, Edmonton, Alta. 109 pp.

CARRUTHERS, W. 1903. *Stellaria media*: is it poisonous? J. R. Agric. Soc. Engl. **64**: 296–309.

CASE, A. A. 1957. Some aspects of nitrate intoxication in livestock. J. Amer. Vet. Med. Assoc. **130**: 323.

CASPERS, N. 1977. Seasonal variations of caloric values in herbaceous plants. Oecologia (Berl.) **26**: 379–383.

CHAMPNESS, S. S. and MORRIS, K. 1948. The population of buried viable seeds in respect to contrasting pasture and soil types. J. Ecol. **36**: 149–173.

CITIR, A. and VARNEY, E. H. 1974. Common chickweed, a major weed host of turnip mosaic virus in New Jersey. Proc. Amer. Phytopathol. Soc. **1**: 134.

CLARK, G. H. and FLETCHER, J. 1909. Farm weeds of Canada. 2nd ed. Agric. Canada, Ottawa, Ont. 192 pp.

CONNERS, I. L. 1967. An annotated index of plant diseases in Canada and fungi recorded on plants in Alaska, Canada and Greenland. Can. Dep. Agric. Publ. 1251. Ottawa, Ont. 381 pp.

CONVERSE, R. H. and STACE-SMITH, R. 1971. Rate of spread and effect of tomato ringspot virus on red raspberry in the field. Phytopathology **61**: 1104–1106.

COOPER, J. I. and HARRISON, B. D. 1973. The role of weed hosts and the distribution and activity of vector nematodes in the ecology of tobacco rattle virus. Ann. Appl. Biol. **73**: 53–66.

FEDEROV, A. A. 1974. Chromosome numbers of flowering plants. Reprint by Otto Koeltz Science Pubs., Koenigstein, W. Germany. 926 pp.

FERRON, M. and CAYOUETTE, R. 1975. Noms des mauvaises herbes du Québec. 3^{e} ed. Min. Agric. Colonisation , Québec. 113 pp.

FRANKTON, C. and MULLIGAN, G. A. 1970. Weeds of Canada. Can. Dep. Agric. Publ. 948. Canada Supply and Services, Ottawa, Ont. 217 pp.

FRYER, J. D. and EVANS, S. A. (eds.) 1968. Weed control handbook, vol. 2 — Recommendations. 5th ed. Blackwell, Oxford, Gr. Br. 325 pp.
FRYER, J. D. and MAKEPEACE, R. J. 1977. Weed control handbook, vol. 1 — Principles. 7th ed. Blackwell, Oxford, Gr. Br. 510 pp.
GILBERT, B. E. and PEMBER, F. R. 1935. Tolerance of certain weeds and grasses to toxic aluminum. Soil Sci. **39**: 425–429.
GILKEY, H. M. 1957. Weeds of the Pacific Northwest. Oregon State College, Portland, Ore. 441 pp.
GRIEVE, M. 1959. A modern herbal, vol. 1. Hafner Publ., New York, N.Y. 427 pp.
GROH, H. and FRANKTON, C. 1946. Canadian weed survey fifth report. Agric. Canada, Ottawa, Ont. 86 pp.
GROH, H. and FRANKTON, C. 1948. Canadian weed survey seventh report. Agric. Canada, Ottawa, Ont. 144 pp.
HATFIELD, A. W. 1970. How to enjoy your weeds. Fredrick Muller, London, Gr. Br. 116 pp.
HEATHCOTE, G. D. and BYFORD, W. J. 1975. Surveys of sugar-beet seed crops, mangold clamps and weeds in England for aphids and viruses, 1963-1973. J. Agric. Sci. **84**: 87–95.
HITCHCOCK, C. L. and CRONQUIST, A. 1973. Flora of the Pacific Northwest. Univ. of Washington Press, Seattle, Wash. 730 pp.
HULTÉN, E. 1970. The circumpolar plants. 2. Dicotyledons. (cont'd. from Sv. Vet. Akad. Handl. Band. 8 Nr 5). Almquist and Wiksell, Stockholm, Sweden. 275 pp.
KING, L. J. 1966. Weeds of the world; biology and control. Plant Sci. Monogr. Intersci. Publ. Inc., New York, N.Y. 526 pp.
KNUTH, P. 1908 Handbook of flower pollination. Vol. 2. Rananculaceae to Stylidieae. Clarendon Press, Oxford, Gr. Br. 703 pp.
KRAFT, E. 1917. Experimentelle und entwickelungsgeschichtliche Untersuchungen an Caryophyllaceen — Blüten. Flora **109**: 283–356.
LAWSON, H. M. 1972. Weed competition in transplanted spring cabbage. Weed Res. **12**: 254–267.
LEFEVRE, P. 1956. Influence de milieu et des conditions d'exploration sur le développement des plantes adventices. Effet particulier du pH et l'état calcique. Ann. Agron. Paris **7**: 299–347.
LONG, H. C. 1938. Weeds of arable land. Bull. 108, Min. Agric. and Fish., London, Gr. Br. 215 pp.
LOUSLEY, J. E. 1971. The flora of the isles of Scilly. Redwood Press, London. 336 pp.
LÖVE, A. and LÖVE, D. 1975. Cytotaxonomical atlas of the Arctic flora. Cramer, Vaduz. 598 pp.
MANN, H. H. and BARNES, T. W. 1950. The competition between barley and certain weeds under controlled conditions. 4. Competition with *Stellaria media*. Ann. Appl. Biol. **37**: 139–148.
MATZKE, E. B. 1932. Flower variations and symmetry patterns in *Stellaria media* and their underlying significance. Amer. J. Bot. **19**: 477–507.
MOORE, R. J. (ed.) 1973. Index to plant chromosome numbers 1967-1971. Utrecht, Netherlands, International Bureau for Plant Taxonomy and Nomenclature. 539 pp.
MOSS, C. E. 1914. The Cambridge British flora. vol. 3: Portulacaceae to Fumariaceae. Cambridge University Press, Cambridge, Gr. Br. 200 pp.
MUENSCHER, W. C. L. 1955. Weeds, 2nd ed. Macmillan, New York, N.Y. 560 pp.
MULLIGAN, G. A. 1961. Chromosome numbers of Canadian weeds. *3*. Can. J. Bot. **39**: 1057–1066.
MULLIGAN, G. A. and FINDLAY, J. N. 1970. Reproductive systems and colonization in Canadian weeds. Can. J. Bot. **48**: 859–860.
MULLIGAN, G. A. and KEVAN, P. G. 1973. Color, brightness and other floral characteristics attracting insects to the blossoms of some Canadian weeds. Can. J. Bot. **51**: 1939–1952.
MULLVERSTEDT, R. 1963. Untersuchungen uber die Keimung von Unkrautsamen in Abhangigkeit von Saverstoffpartialdruck. Weed. Res. **3**: 154–163.
NABER, H. and LUFTEN, W. 1972. Chickweed in grassland and its control. Bedrijfson Wikkeling **3**: 911–913.
ONTARIO HERBICIDE COMMITTEE. 1978. Guide to chemical weed control. Min. of Agric. and Food, Toronto, Ont. Publ. 75, 103 pp.
O'LEARY, T. E. 1973. Broad-leaved weed infestations in cereals. Agric. Tech., Spring, 37–41. Fisons, Agrotechnical Div., Harston, Cambridge, Gr. Br.
PEDERSEN, A. 1972. Adventitious plants and cultivated plants in Greenland. Meddelelser om Grønland. **178**, (7), 98pp.
PETERSON, D. 1933. *Stellaria media* L. × *Stellaria neglecta* Weihe. Bot. Notiser. pp. 500–504.
PETERSON, D. 1936. *Stellaria*-Studien. Zur Zytologie, Genetik, Ökologie und Systematik der Gattung *Stellaria*, insbesondere der *media*-Gruppe. Bot. Notiser. pp. 281–419.

PROCTOR, M. and YEO, P. 1973. The pollination of flowers. Collins, London, Gr. Br. 481 pp.
PROVVIDENTI, R. 1975. Natural infection of *Celosia argenta* by cucumber mosaic virus in a commercial greenhouse. Plant Dis. Rep. **59**: 166–168.
REINÖHL, F. 1903. Die Variation im Androecium der *Stellaria media* Cyr. Bot. Zeit. **61**: 159–200.
RICHARDS, W. R. 1976. A host index for species of Aphidoidea described during 1935 to 1969. Can. Entomol. **108**: 499–550.
ROBERTS, H. A. 1962. Studies on the weeds of vegetable crops. 2. Effect of six years of cropping on the weed seeds in the soil. J. Ecol. **50**: 803–813.
ROBERTS, H. A. 1964. Emergence and longevity in cultivated soil of seeds of some annual weeds. Weed. Res. **4**: 296–307.
ROBERTS, H. A. and DAWKINS, P. A. 1967. Effect of cultivation on the numbers of viable weed seeds in soil. Weed Res. **7**: 290–301.
ROBERTS, H. A. and LOCKETT, P. M. 1975. Germination of buried and dry-stored seeds of *Stelleria media*. Weed Res. **15**: 199–204.
ROUSSEAU, C. 1968. Histoire, habitat et distribution de 220 plantes introduites au Québec. Natur. Can. **95**: 49–171.
SALISBURY, E. J. 1964. Weeds and aliens. Collins, London, Gr. Br. 384 pp.
SALISBURY, E. J. 1974. The variation in the reproductive organs of *Stellaria media* (sensu stricto) and allied species with special regard to their relative frequency and prevalent modes of pollination. Proc. R. Soc., London, Ser. B. **185**: 331–342.
SCHULZ, H. 1970. The effect of differential cropping on the plant composition, yield, and chemical contents of two permanent grassland areas. Z. Acker. Pflanz. **131**: 233–250.
SINHA, R. P. and WHITEHEAD, F. H. 1965. Meiotic studies of British populations of *Stellaria media* (L.) Vill., *S. neglecta* Weihe and *S. pallida* (Dumort.) Piré. New Phytol. **64**: 343–345.
SMITH, K. M. 1972. A textbook of plant virus diseases. 3rd ed. Longman, London, Gr. Br. 684 pp.
SPENCER, E. R. 1940. Just weeds. Scribner, New York, N.Y. 317 pp.
STACE, C. A. 1975. Hybridization and the flora of the British Isles. Academic Press, London, Gr. Br. 626 pp.
STALDER, L., POTTER, C. A. and BARBEN, E. 1973. New herbological aspects in viticulture: weed control or management? Schweiz. Z. Obst. Weinbau **109**: 246–261.
TAYLOR, R. L. and MACBRYDE, B. 1977. Vascular plants of British Columbia: A descriptive resource inventory. Tech. Bull. No. 4, The Botanical Garden, University of British Columbia. University of B.C. Press, Vancouver, B.C. 754 pp.
TAYLOR, R. L. and MULLIGAN, G. A. 1968. Flora of the Queen Charlotte Islands. Part 2. Cytological aspects of the vascular plants. Queen's Printers, Ottawa, Ont. 148 pp.
TOMLINSON, J. A. and CARTER, A. L. 1970. Studies on the seed transmission of cucumber mosaic virus in chickweed (*Stellaria media*) in relation to the ecology of the virus. Ann. Appl. Biol. **66**: 381–386.
TOMLINSON, J. A. and WALKER, V. M. 1973. Further studies on seed transmission in the ecology of some aphid-transmitted viruses. Ann. Appl. Biol. **73**: 293–298.
TOMS, H. N. 1964. Plant diseases of Southern British Columbia — A host index. Can. Plant Dis. Surv. **44**(3): 143–225. Res. Br., Can. Dep. Agric., Ottawa, Ont.
TOOLE, E. H. and BROWN, E. 1946. Final results of the Duvel buried seed experiment. J. Agric. Res. **72**: 201–210.
WALKEY, D. G. A. and COOPER, E. J. 1976. Growth of *Stellaria media*, *Capsella bursa-pastoris*, and *Senecio vulgaris* plantlets from cultivated meristem tips. Plant Sci. Lett. **7**: 179–186.
WALTON, D. W. H. 1975. European weeds and other alien species in the subantarctic. Weed Res. **15**: 271–282.
WHITEHEAD, F. H. and SINHA, R. P. 1967. Taxonomy and taximetrics of *Stellaria media* (L.) Vill., *S. neglecta* Weihe and *S. pallida* (Dumort.) Piré. New Phytol. **66**: 769–784.