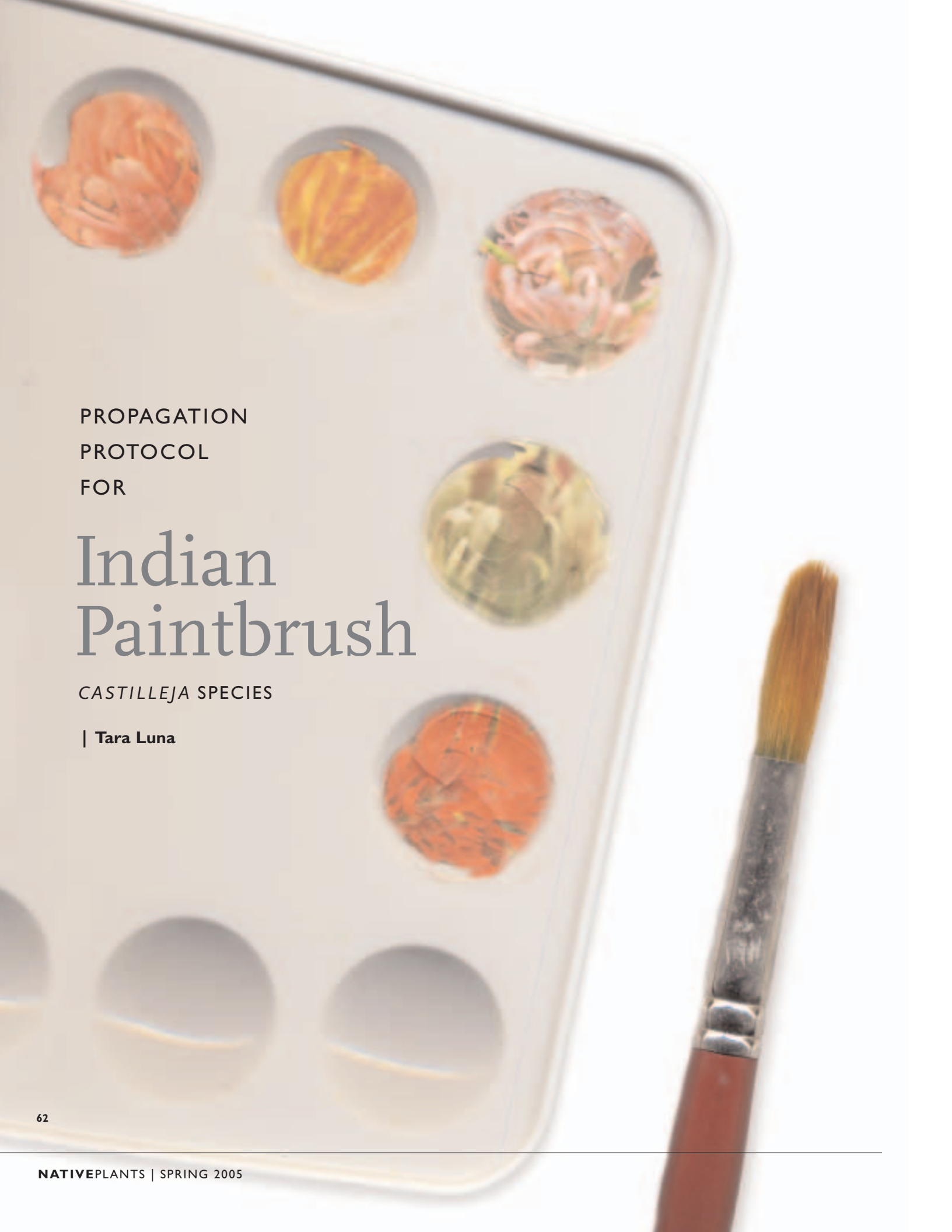

PROPAGATION PROTOCOL FOR

Indian Paintbrush

CASTILLEJA SPECIES

| **Tara Luna**

Indian paintbrush (*Castilleja* spp. Michx. [Scrophulariaceae]) is a vibrant, beautiful genus of annual, biennial, and perennial wildflowers that are found exclusively in North America. The majority of species grow in the West, but a few species occur in the central portion of the US. There are more than 150 species and many freely hybridize with one another in areas where their ranges overlap. They are found in a wide range of habitats, ranging from low elevation wetlands and riparian areas to dry grasslands, steppe-shrub communities, and rocky slopes to mid- to high elevation mountain meadows and slopes.

The inflorescence is a short or elongate terminal spike bearing tubular-shaped flowers that are subtended by numerous colorful bracts. Indian paintbrush is appropriately named as the bracts graduate in color from green leafy stems to the brightly colored tops of the inflorescence, thus giving the appearance that the tops of the plants have been dipped in paint. Both insects and hummingbirds are attracted to these plants and serve as pollinators.

The flower and bract color, even within a single species, can range wildly across the color palette from rich reds, scarlet, and fuchsia to orange, salmon, pink, yellow, and cream. It is not unusual to find a single flower with up to 3 contrasting colors on the showy bracts. Because the floral bracts make up most of the color, they tend to remain showy for several weeks through the growing season. The rich, brilliant, prolonged color of these species is one reason why they are some of the most desired native species for the home landscape, yet they are not widely available for sale as container plants because of their interesting biology.

Paintbrush species, as well as some other genera in the figwort family (Scrophulariaceae), have a unique biology known as hemi-parasitism. Unlike a true parasitic plant, hemi-parasites are capable of manufacturing their own food and obtaining water and nutrients from soil, but they also form specialized roots known as haustoria roots that attach to the roots of a host plant, thereby providing additional water uptake for the paintbrush plant and possibly some organic and inorganic nutrients. This relationship does not kill the host. Seeds do not require a signal from the host to initiate germination, and they contain endosperm that provides enough energy for the seedling to establish independently (Press 1989). Unless a haustorium root becomes attached to a host root, however, they will decline in vigor, remain stunted in growth, and never flower, or they will eventually die. The degree that a species can grow and develop without the host may vary widely between species.

Over the years, my fascination with this beautiful group of plants has led me to try growing, in containers, many different species from a wide variety of habitats. Here is my technique for growing *Castilleja* from seeds.

KEY WORDS

Castilleja angustifolia, *applegatei, cusickii, exilis, hispida, indivisa*, *integra*, *linariifolia, lutescens*, *miniata, minor*, *nivea*, *occidentalis*, *pallescens*, *pulchella*, *purpurea, rhexiifolia, scabrida, sessiliflora, sulphurea,* seed propagation, hemi-parasitism, stratification

NOMENCLATURE

USDA NRCS (2004)

Pages 64 and 65. *C. purpurea.* Photos by Tara Luna

SEED COLLECTION

Indian paintbrush is relatively easy to propagate from seeds. Seeds can be collected in midsummer for early spring flowering species and in late summer for mid-elevation species. High elevation species are collected during fall. In general, the dry dehiscent seed capsules ripen 8 to 10 w following pollinator activity. There are many tiny seeds per capsule. These are grayish to tan in color with a somewhat wrinkled or pitted surface.

SEED TREATMENT

In a study, seeds of 8 western US Indian paintbrush species were essentially completely dormant without cold moist stratification (Meyer and Carlson 2004). Species and populations within species responded to cold moist stratification to at least some degree. In general, populations from warmer, low elevation sites had shorter chilling requirements and more rapid germination following cold moist stratification than populations and species from higher and colder sites. But there were distinctive differences among species. The requirement for some period of cold moist stratification, even in after-ripened seeds held in dry storage, is related to the fact that Indian paintbrush species generally have spring-emerging seedlings (Meyer and Carlson 2004).

I imbibe freshly collected seeds in water for 4 to 8 h and pour off the water and any fine debris that might serve as a source of fungal contamination during stratification. I place imbibed seeds of perennial species into cold moist stratification for 30 to 150 d, depending on species, between layers of blotter paper in either open plastic bags or in Petri dishes in the refrigerator at 1 to 2 °C (33 to 36 °F). I inspect seeds at least once per week to ensure that the paper and seeds stay evenly moist. Seeds of host plants (see next section) are also stratified as required so that host and *Castilleja* seeds are ready for sowing at the same time.

Annual species of Indian paintbrush germinate fairly well without stratification, although more uniform emergence is obtained by stratifying seeds for 30 d at 3 °C (38 °F) prior to sowing.

SELECTING A HOST

I select a host plant for companion planting that occurs in the same habitat as the paintbrush. The host plant should be small in stature with a non-aggressive or weakly rhizomatous root system so that it does not out-compete the developing paintbrush seedling in the container. Species that work well as hosts

include beardtonque (*Penstemon* spp. [Scropulariaceae]), jacob's ladder (*Polemonium pulcherrimum* Hook. [Polemoniaceae]), tufted sedges such as thread leaf sedge (*Carex filifolia* Nutt. [Cyperaceae]), and small bunchgrasses such as Idaho fescue (*Festuca idahoensis* Elmer [Poaceae]). These work very well for western perennial Indian paintbrush species that occur in dry habitats and grasslands. For mountain and alpine species, I use small alpine sedges such as Payson's sedge (*Carex paysonsis* Clokey) or black and white sedge (*Carex albonigra* Mackenzie). For the annual *Castilleja minor* from New Mexico, I have used pineneedle beardtongue (*Penstemon pinifolius* Greene) and a tufted grass such as Indian ricegrass (*Achnatherum hymenoides* (Roemer & J.A. Schultes) Barkworth). For the Montana source of *C. minor* (formerly *C. exilis*), I used Idaho fescue. I have used Drummond phlox (*Phlox drummondii* Hook. [Polemoniaceae]) or Texas bluebonnet (*Lupinus texensis* Hook) [Fabaceae]) as hosts for the annual *Castilleja indivisa.*

GERMINATION, MEDIUM, AND FERTILIZATION

Following stratification, I sow the tiny seeds of Indian paintbrush very shallowly into containers and cover them lightly with perlite mulch or a fine chicken grit mulch to hold them in place. Because the host is not required for seed germination, I sow a flat of host plants separately.

Most Indian paintbrush species will germinate well at moderate alternating greenhouse temperatures of 21 to 25 °C (69 to 77 °F) day and 10 to 16 °C (50 to 60 °F) night. Many northern and high elevation species, however, germinate to higher percentages at cooler temperatures. These cool-temperature requiring species are best sown as germinants as seed dormancy is broken in the refrigerator, or stratified seeds can be sown outdoors in early spring where they are subjected to natural fluctuating day and night temperatures that progress from cool to warmer temperatures during the spring months (Table 1). They can also be sown outdoors in fall. Stratified seeds tend to germinate and emerge 10 to 14 d after sowing in the greenhouse, although high elevation species and seed sources tend to germinate more slowly and over a several week period, even after a prolonged cold moist stratification. These must also be germinated and grown under cool temperatures as warm air and growing medium temperatures can adversely affect their growth.

In the species and seed sources used, I have observed that germination percentages tend to be higher with seeds

from low to mid-elevations and/or from warmer climates, whereas subalpine and alpine species tend to have lower germination percentages. Some seeds of these species and/or seed sources may be highly dormant, even after a prolonged cold moist stratification and when cool germination and growing temperatures are provided. Some seeds of these species germinated the following year in early spring after a second winter, but overall germination percentages were still low (< 40%).

The annual *Castilleja minor* differed slightly in germination behavior between seed sources collected in Montana (formerly *C. exilis*) and New Mexico (*C. minor*). Seeds from Montana germinated better at cooler temperatures than the New Mexico seed source, but overall germination percentages for both seed sources were high (> 85%) (Table 1).

I use 2 different growing media depending on species. Dryland and upland species inhabiting rocky or well-drained soils are grown in 2:1:1 (v:v:v) mix of Sunshine Mix #2 (Sungro Horticulture Inc, Bellevue, Washington), large grade perlite, and sharp sterile sand. Species inhabiting riparian areas or moist high elevation meadows rich with organic matter are grown in pure Sunshine Mix #2 commercial growing medium. I grow perennial species in 116 ml (7.0 in^3) Ray Leach™ containers and annual species in 116 ml (7.0 in^3) containers or Deep 606 traypaks (6 cells/pak).

It is important to keep stratified seeds and planted germinants evenly moist after sowing. They have very little root mass in relation to shoot mass during early development, will wilt quickly if watered stressed, and recover poorly after wilting. Later on, presumably after the host relationship is established and more feeder roots develop, they can be watered thoroughly and allowed to dry down slightly between irrigations.

Indian paintbrush seedlings can develop 4 to 6 sets of true leaves in about 4 to 6 wk after germination. By this time, the fine, unbranched haustoria roots will be well developed and will seek out host roots. I usually pair Indian paintbrush with its host at this time. I have observed that some species of Indian paintbrush will grow and develop well without a host plant in the container for the first 10 to 15 wk, however, seedlings will start to decline in vigor and growth and usually do not re-emerge the second year after the winter storage period or after outplanting. Other species appear to develop an association with the host plant earlier and will not grow much beyond the establishment phase without a host in the container.

During active growth, paintbrush seedlings can be fertilized with a very

low concentration of complete fertilizer ($20N:20P_2O_5:20K_2O$) at one-quarter the label recommended rate. Seedlings should be regularly inspected to ensure that the host plant is not shading the paintbrush seedling, and host leaves can be trimmed to ensure adequate light is available. During midsummer, seedlings grown in the greenhouse are moved outdoors to undergo hardening for at least 4 wk prior to outplanting.

OUTPLANTING

Typically, most species of Indian paintbrush are ready for outplanting 16 wk after germination. Subalpine and alpine species and other species or seed sources that are sown as germinants during stratification will be staggered in age and size. These should be grown in Ray Leach™ containers so they can be easily sorted by size into separate trays. Enough seeds of these species should be sown so that target numbers of seedlings of the same age class are met.

Care should be given so that paintbrush stems, which can be somewhat brittle, are not snapped off during extraction from the container. All of the perennial species I have grown have flowered the second year after germination. The annual to biennial *Castilleja indivisa* and *Castilleja minor* flower approximately 15 wk after germination and tend to grow more rapidly than perennial species, as long as a host is present in the container.

SUMMARY

Given the apparent interest in Indian paintbrush species as a native plant for the home landscape, growers can supply the market with a wide variety of species, as long as careful attention is given to the cold moist stratification requirements of the species and seed sources used. It is also important to provide appropriate germination and growing temperatures, a suitable growing medium for the species, and a host plant in the container at some point during seedling growth. Annual to biennial species do not require stratification but do tend to germinate more uniformly if cold moist stratified for 30 d. Low to mid-elevation and warm climate perennial species and seed sources germinate to higher percentages following cold moist stratification. Fresh seeds of high elevation seed sources and species tend to have low germination percentages, so growers will need to collect, stratify, and sow enough seeds to meet target numbers the first year.

TABLE 1

Range, flowering period, and selected propagation requirements for 20 Castilleja *species.*

Species	Common name	Range	Flowering time	Stratification requirement (d)	Temperature [z] Germination (°C)	Temperature [z] Growing (°C)
C. angustifolia (Nutt.) G. Don	Northwestern Indian paintbrush	MT, ID, WY, OR, NV, UT	Late May to early Jul	60 to 90	21 to 25 day 10 to 16 night	
C. applegatei Fern.	Wavy leaf Indian paintbrush	Mid to high elevations, all western US states except WA	May to Aug	90 to 120	21 to 25 day 10 to 16 night	
C. cusickii Greenm.	Early yellow paintbrush	Mid to high elevations, southern BC and AB, WA, OR, NV, ID, MT	Late Apr to early Aug	90 to 120	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. hispida Benth.	Harsh paintbrush	Low to mid elevations, BC and AB, MT, ID, WA, OR	May to Jun	60 to 90	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. indivisa Engelm.	Texas annual paintbrush	Low elevations, TX, OK, LA, AR	Apr to May	30	21 to 25 day 10 to 16 night	
C. integra Gray	Wholeleaf Indian paintbrush	Low to mid elevations, TX, NM, CO, AZ, northern Mexico	Jun to Aug	30 to 60	21 to 25 day 10 to 16 night	
C. linariifolia Benth	Wyoming Indian paintbrush	Mid to high elevations, all western US states except WA	May to Aug	60 to 90	21 to 25 day 10 to 16 night	
C. lutescens (Greenm.) Rydb.	Stiff yellow Indian paintbrush	Low to mid elevations, southern BC and AB, MT, ID, WA, OR	May to Aug	60 to 90	21 to 25 day 10 to 16 night	
C. miniata Doug. ex Hook.	Giant Indian paintbrush	Low to mid elevations; BC and AB; all western US states and ND	May to Aug	60 to 120	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. minor (Gray) Gray (NM seed source)	Annual lesser paintbrush	Low to mid elevations, southern AB south to all western US states, northern Mexico	Late May to Jun	30	21 to 25 day 10 to 16 night	

Species	Common name	Range	Flowering time	Stratification requirement (d)	Temperature [z] Germination (°C)	Growing (°C)
C. minor (Gray) Gray (MT seed source)	Lesser paintbrush	Low to mid elevations, southern AB south to all western US states, northern Mexico	Jun	30	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. nivea Pennell & Ownbey	Snow Indian paintbrush	High elevation meadows in MT and WY	Jul to Aug	120 to 150	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. occidentalis Torr.	Western Indian paintbrush	High elevation meadows, from AB to NM	Late Jul to Aug	90 to 150	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. pallescens (Gray) Greenm.	Pale Indian paintbrush	Low to mid elevations, MT, ID, WY, NV, OR	Late May to Jun	90	21 to 25 day 10 to 16 night	
C. pulchella Rydb.	Beautiful Indian paintbrush	High elevation meadows in MT, ID, WY, UT	Jul and Aug	90 to 150	10 to 20 day 10 to 16 night	
C. purpurea (Nutt.) G. Don var. *purpurea*	Prairie Indian paintbrush	Low elevations, KS, OK, TX	Apr and May	30 to 60	21 to 25 day 10 to 16 night	
C. rhexiifolia Rydb. [y]	Rhexi-leaf paintbrush	High elevations, BC and AB and south to NV and NM	Jul and Aug	90 to 150	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. scabrida Eastw.	Slickrock paintbrush	Mid elevations, CO, UT, NV	Apr to May	30 to 60	21 to 25 day 10 to 16 night	
C. sessiliflora Pursh	Downy paintbrush	Low to mid elevations, southern AB, MT, WY, CO, NM and AZ, ND to TX, east to IL, MO, WI	Apr to Jun	60 to 90	10 to 20 day 10 to 16 night	21 to 25 day 10 to 16 night
C. sulphurea Rydb.	Sulphur Indian paintbrush	Mid to high elevations, AB south to NM, AZ, west to WA, ID and east to SD	Jun to Jul	60 to 90	21 to 25 day 10 to 16 night	

[z] Temperature conversions: 10 to 16 °C = 50 to 60 °F, 10 to 20 °C = 50 to 68 °F, 21 to 25 °C = 69 to 77 °F

[y] See Dumroese and Skinner (2005)

REFERENCES

Dumroese RK, Skinner MW. 2005. *Rhexifolia* versus *rhexiifolia:* plant nomenclature run amok? Native Plants Journal 6:59–60.

Meyer SE, Carlson SL. 2004. Comparative seed germination biology and seed propagation of eight Intermountain species of Indian paintbrush. In: Hild AL, Shaw NL, Meyer SE, Booth TD, McArthur ED, compilers. Proceedings: seed and soil dynamics in shrubland ecosystems; 2002 Aug 12–16; Laramie, WY. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings. RMRS-P-31. p 125–129.

Press MC. 1989. Autotrophy and heterotrophy in root hemiparasites. Trends in Ecology and Evolution 4:258–263.

[USDA NRCS] USDA Natural Resources Conservation Service. 2004. The PLANTS database, version 3.5. URL: http://plants.usda.gov (accessed 6 Jan 2005). Baton Rouge (LA): National Plant Data Center.

AUTHOR INFORMATION

Tara Luna
Botanist
PO Box 447
East Glacier Park, MT 59434
tluna@3rivers.net