that the next season's growth is very full. The second seasons growth is very vigorous as was the first and the development of the caliper continues and with proper pruning being done we have a salable plant by the end of the second season.

We feel that one of the main reasons for this phenomenal accelerated growth is the quantity of roots on the tree. When a tree is spring planted into cold wet soil it has to develop a root system from it's cut roots quickly, which it can not do because of the soil temperatures, while at the same time it is trying to put on top growth. Our fall-planted liners already have roots established.

My observations as a nurseryman for years has been that a tree seems to transplant better if I cut multiple small roots rather than several very large roots; this is exactly the type of root system that develops from a 'Spin-Out™-treated containerized tree. Another advantage of fall planting containerized tree liners is the total elimination of the root pruning process we all go through with bareroot liners. It now takes us less time to plant our entire crop then it used to take just to root prune our bareroot plants.

Genotypic and Environmental Effects on Root Cutting Propagation of *Pulmonaria* Species and Cultivars

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INTRODUCTION

Root cutting propagation is the technique in which plant roots are severed from the mother plant, cut into individual pieces, placed under moist, warm conditions, and allowed to develop into new plants after the formation of adventitious buds and roots. The propagation of ornamentals by root cuttings is an economical and efficient technique for some plant species. However, it is a method that is underutilized and should be given greater attention by plant propagators. The increasing costs of cutting production make it worthwhile for propagators to evaluate root cutting propagation as a possible means to increase plant production and decrease costs.

Root cutting propagation has several advantages: it can be carried out with unskilled labor, provides a fast way to multiply clonal material, requires limited propagation facilities, is useful for some plants where other methods have not been found satisfactory, is useful when only one sex of a dioecious plant is required, and can be carried out during the winter when weather is unsuitable for outdoor work. There are some disadvantages — these include limited information on the number of potential plants that can be obtained from stock plants, variability of results from year to year for some species, potential "weed" problems of severed roots that remain in a stock plant area, inconvenience of handling roots from outside stock plants if they are not sufficiently washed, variability in production as a result of the time of year cuttings are made, and the problem of propagating chimeral variegated plants.

Pulmonaria species, commonly called the lungworts, are one of the "hottest" groups of perennial plants for the shade garden. They are low-growing, clump-forming plants that grow best in full to part shade in moist soil. Some *Pulmonaria*

species produce white or red flowers, but most species produce blue or pink flowers in the early spring; the flowers typically open one color, usually pink, and then turn blue as they age. This flower characteristic has given rise to the common name of soldiers and sailors. Flowers open before the foliage emerges or at the same time. After flowering, *Pulmonaria* species continue to be attractive with dark green, elliptical basal leaves that are covered with a bristly pubescence; many of the most popular cultivars are flecked with white spots.

Pulmonaria species are usually propagated by division, but they can also be propagated by seed for flowering in the 2nd year. The purpose of this study was to determine if *Pulmonaria* could also be propagated by root cuttings.

OBJECTIVES

The objectives of this research were:

1) To determine which genotypes of *Pulmonaria* species responded to root cutting propagation.
2) To learn what time of year is best to take root cuttings from *Pulmonaria*.
3) To discover if distal root cuttings of *Pulmonaria* respond differently to root propagation than proximal root cuttings.

PROCEDURES

There were eight different *Pulmonaria* cultivars that were studied (Table 1). There was one each of *P. longifolia* × *P. saccharata, P. saccharata, P. officinalis, P. angustifolia, P. rubra*, and *P. longifolia.*

Table 1. *Pulmonaria* species and cultivars that were evaluated for root-cutting propagation.

Species	Cultivar
Pulmonaria saccharata	'Janet Fisk'
Pulmonaria vallarsae	'Margery Fish' (syn. *P. saccharata* 'Margery Fish')
Pulmonaria	'Lewis Palmer' (syn. *P. saccharata* 'Highdown')
Pulmonaria	'Roy Davidson'
Pulmonaria officinalis	'Sissinghurst White'
Pulmonaria angustifolia	'Johnson's Blue'
P. rubra	'Redstart'
Pulmonaria longifolia	'Bertram Anderson'

During the first week of each month, for 12 consecutive months, 15 distal and 15 proximal root cuttings were removed from stock plants of each cultivar. Stock plants were maintained outside in a protected hotbed at natural daylengths, winter temperatures did not fall below 0C. Root cuttings were 3 cm long, distal cuttings

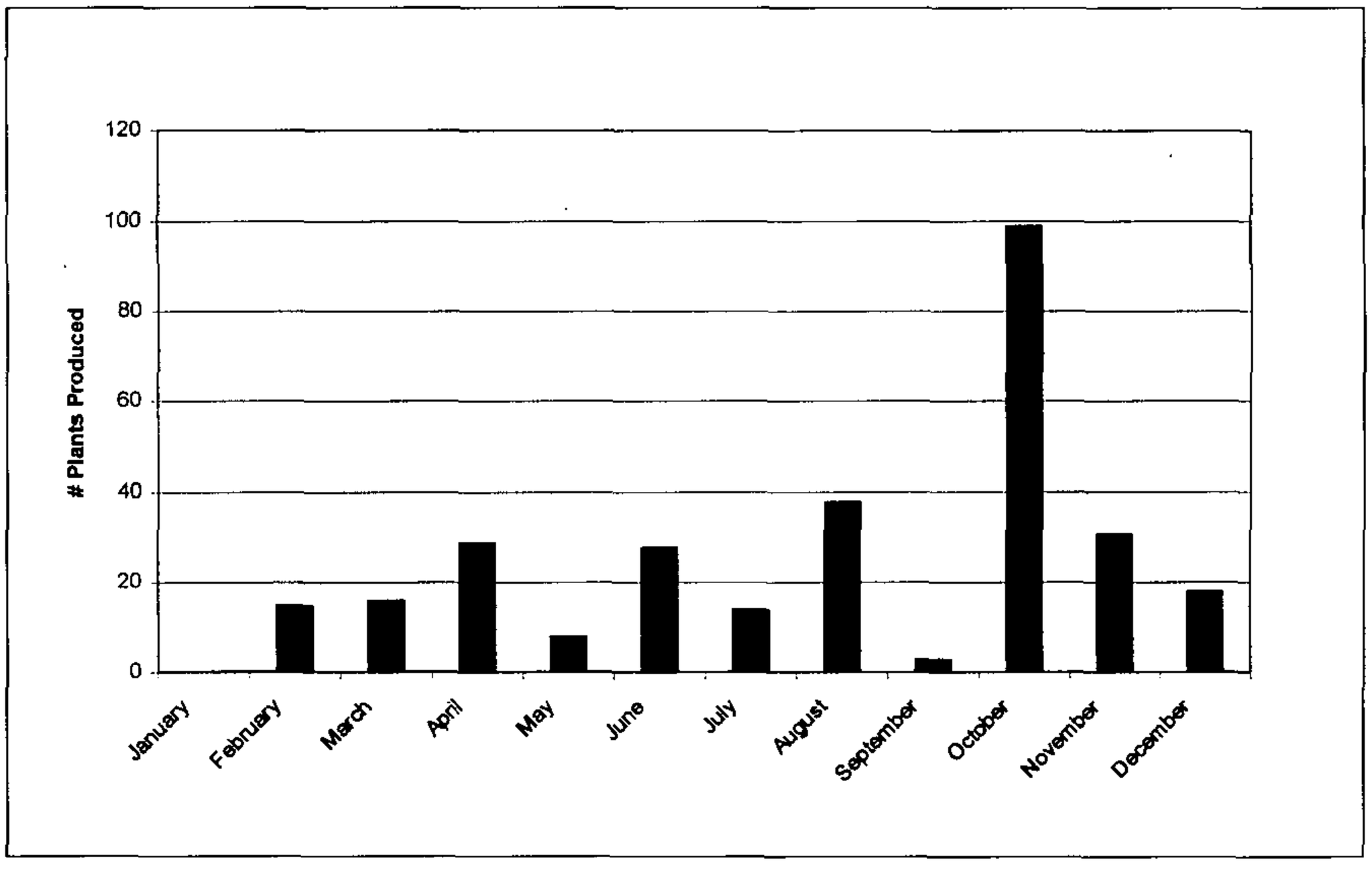

Figure 1. Number of plants produced from root cuttings taken from *Pulmonaria* 'Roy Davidson' over a 12-month period.

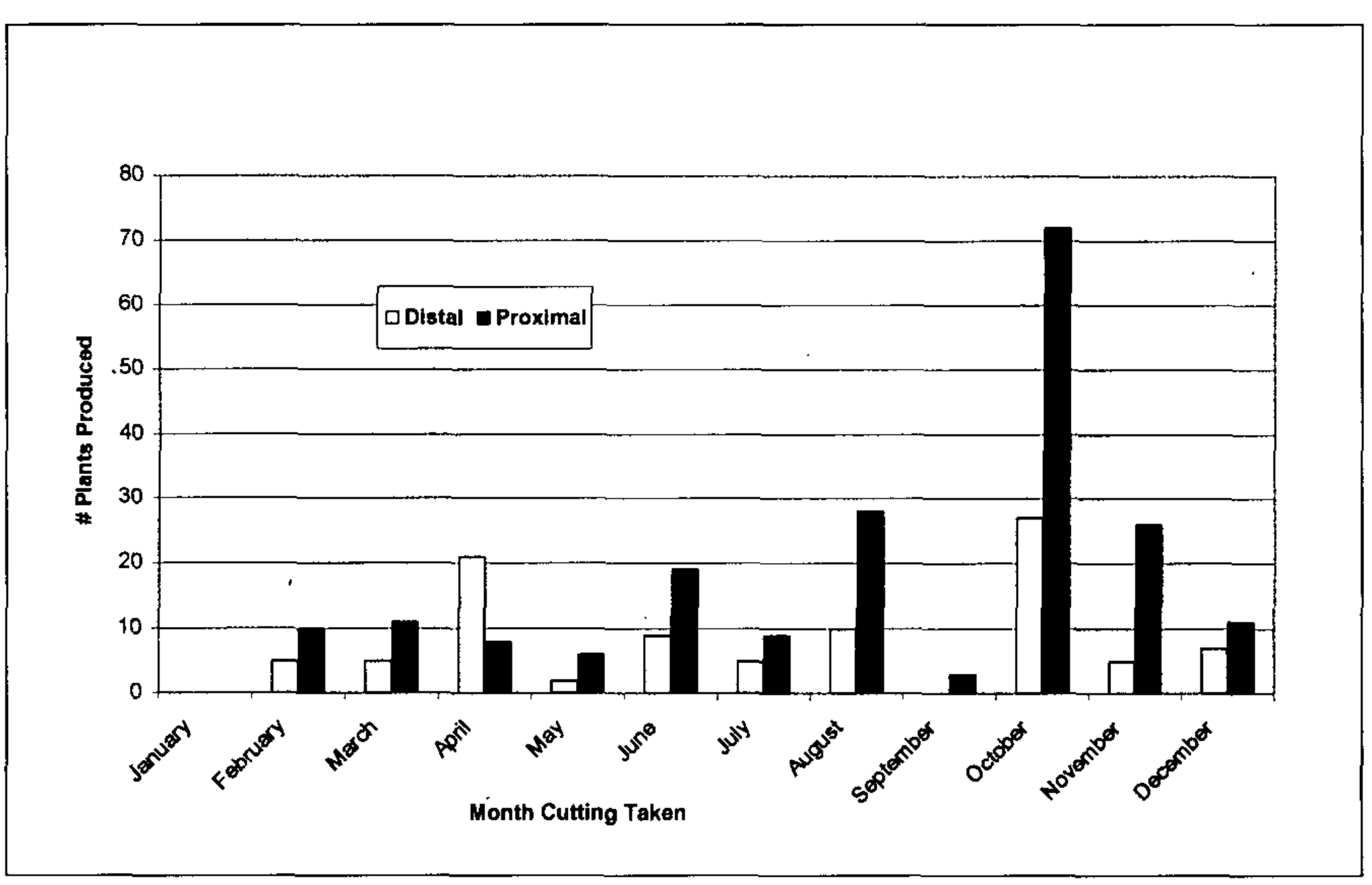

Figure 2. A comparison of the production of plants from distal and proximal root cuttings taken from *Pulmonaria* 'Roy Davidson' over a 12-month period.

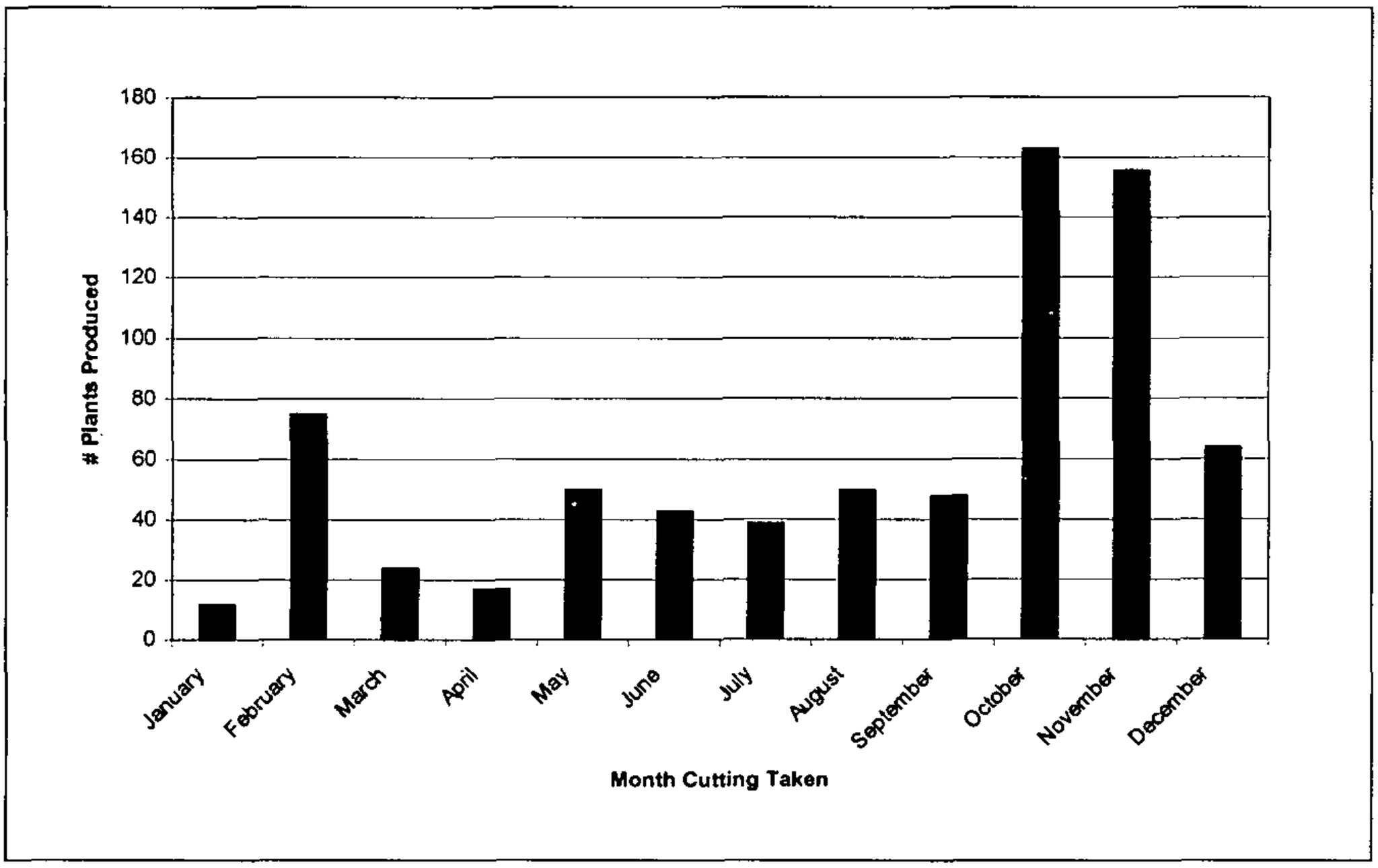

Figure 3. Number of plants produced from root cuttings taken from *Pulmonaria longifolia* 'Bertram Anderson' over a 12-month period.

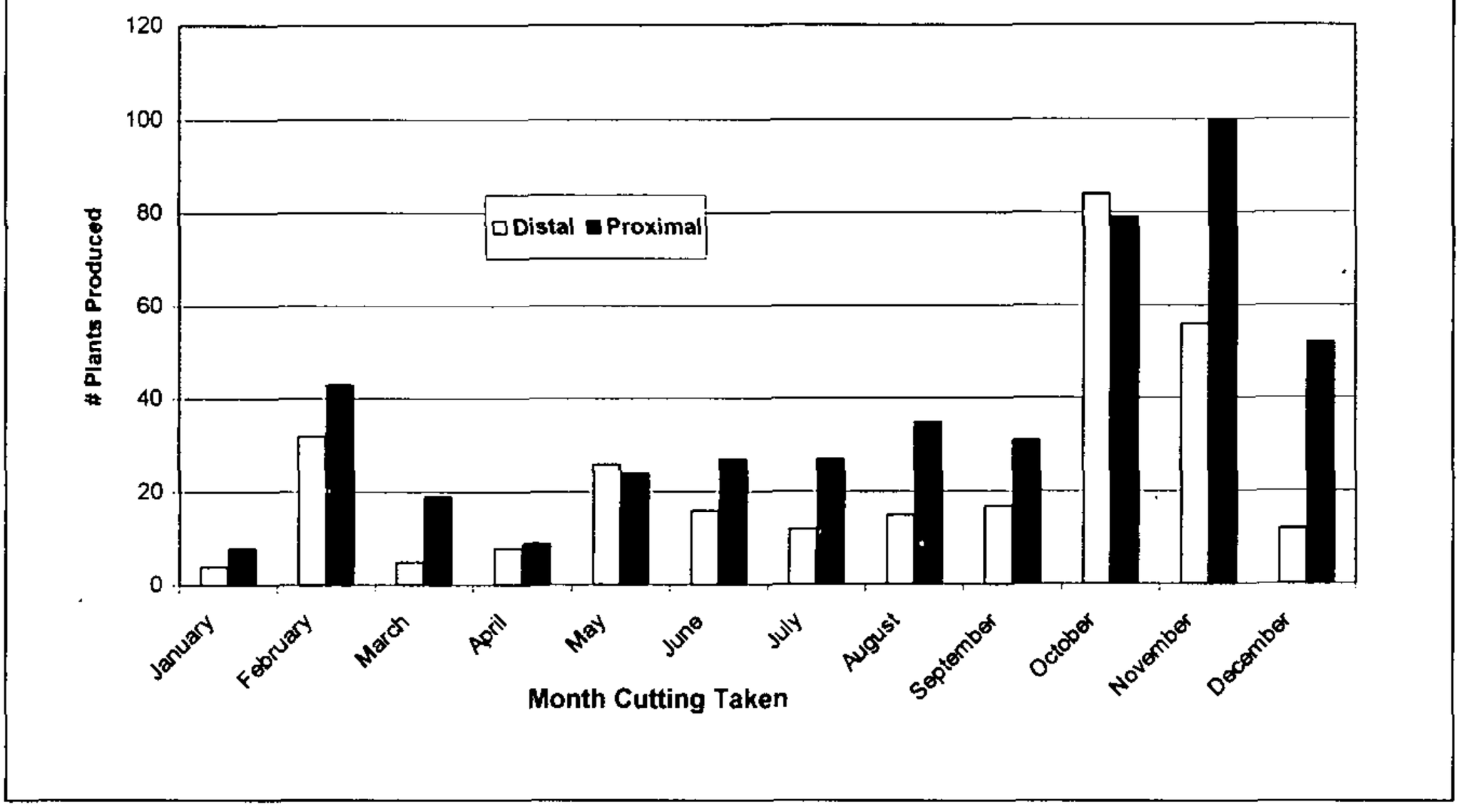

Figure 4. A comparison of the production of plants from distal and proximal root cuttings taken from *Pulmonaria longifolia* 'Bertram Anderson' over a 12-month period.

were approximately 2.5 mm thick at the widest point and proximal cuttings were approximately 3.5 mm thick at the widest point. Root cuttings were placed horizontally, approximately 3 cm deep, into damp Metro Mix 360 medium and maintained in a propagation house at 12C nights. Cuttings were placed in the propagation area in a randomized complete block design over time with five replications per cultivar per month and three samples per replication. The time it took for plants to regenerate from the root cuttings and the number of plants produced per cutting were recorded each week for 16 weeks.

RESULTS

Of the eight cultivars that were tested, the only two to significantly respond to root cutting propagation were 'Roy Davidson' and 'Bertram Anderson'. Root cuttings from the other cultivars produced no or few plants. *Pulmonaria* 'Roy Davidson' produced most of its plants during the months of August, October, and November, with the greatest number being produced in October (Fig. 1). For each month, except April, the number of plants that were produced was significantly greater for proximal cuttings rather than distal cuttings (Fig. 2). A similar response was noticed for *P. longifolia* 'Bertram Anderson'. The greatest number of new plants was produced from root cuttings taken during the months of October and November (Fig. 3). For each month, except May and October, the number of plants that were produced was significantly greater for proximal cuttings rather than distal cuttings (Fig. 4). For both cultivars, the majority of new plants were produced from 4 to 8 weeks after the cuttings were made.

CONCLUSIONS

In this study with *Pulmonaria* species, it became clearly visible that genetics had an effect on the success of root cutting propagation. Of the eight cultivars investigated, the only two to respond, 'Roy Davidson' and 'Bertram Anderson', had the *P. longifolia* genotype. All others failed to produce significant numbers of new plants. Another similarity for both of these cultivars was that the largest number of plants were produced when root cuttings were taken during the fall months of October and November. Evidence was produced that again proves that, for the greatest potential for success, root cuttings should be taken from the larger proximal regions of roots.

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