POPULATION STRUCTURE AND ENVIRONMENTAL COROLLARIES OF *PANAX QUINQUEFOLIUM* (ARALIACEAE) IN DELAWARE COUNTY, NEW YORK

WALTER H. LEWIS

ABSTRACT

A large population of *Panax quinquefolium* from New York is characterized by age structure, morphology, and flowering. Population dynamics are correlated with local climate, the most interesting association being the dramatic increase in population size during 1982 when monthly precipitations between January and June compared favorably with 20-year averages at a time when the need for protective snow cover for seeds and optimum conditions for seed germination would apparently be paramount.

Key Words: *Panax quinquefolium*, American ginseng, population, environment, New York

INTRODUCTION

Panax quinquefolium L. (American ginseng) is a rare or extirpated species in northeastern United States and adjacent Canada where it once thrived. To locate a large population of some age that is expanding in a natural ecosystem is uncommon. Thus, the discovery by Arthur W. Rashap and Edmund Millar of such a population near Roxbury, Delaware County, in the Catskill Mountains of eastern New York, where the species at one time must have been frequent, was important. It prompted me to initiate a study of population dynamics similar to one underway in Missouri (Lewis and Zenger, 1982), which could serve not only as a comparison with this geographically different site, but could apply to programs for re-establishing the species in New York. The first of these goals is partially fulfilled by this report, insofar as population structure is concerned, but the second proved impossible. Within weeks of recording the data on June 30, 1982, the population was eradicated by root diggers.

MATERIALS AND METHODS

The population was found in a well-drained, sloping, deciduous woods with deep humus accumulated from leaf litter. Plants were described, labeled, numbered, and located on a map for future reference. Several were photographed for permanent record and prints are deposited at MO (*Lewis 9778*). Rhizomes were carefully exposed to count bud scars in order to determine ages and then re-covered.

U.S. climatological data for New York include only four stations with precipitation and two having temperature records in Delaware County during a 20-year period from 1963–82. These reports are summarized monthly for a 6-year period, 1977–82, together with 20-year means and standard deviations. The station near Roxbury, which is situated very close to the population, is not included, for recording of data terminated in 1972. Nevertheless, the other county stations are sufficiently near and similar in their situation to present approximate environmental conditions for the population site.

RESULTS AND DISCUSSION

Age structure and morphology

For a population of 211 individuals, ages in 1982 ranged from 1 to 21 years (Table 1), plus an exceptional plant 48 years old. This plant not only was 27 years older than the next oldest plant in the population, but the aerial stem was strongly flattened and the leaflets were very coarse and thick; it does not figure further in this analysis. A second exceptional plant had two aerial stems, one having three prongs (15 leaflets) and an inflorescence with nine flowers, and the other with two prongs (10 leaflets) and seven flowers. For analytical purposes, these stems are considered representative of two plants. The most predominant age class, representing 56.9% of the whole population, was of seedlings that had germinated during the spring of 1982. Plants of two and three years of age were next most common, but each represented only about 10% of the population. Those between 4 and 11 years of age varied from 1.8 to 3.8%, whereas all plants established between 1963 and 1971 were represented by a total frequency of only 3.8%. Thus, annual recruitment represented by surviving plants was gradual for 18 years, followed by modest expansions during 1980 and 1981, and culminated by an explosive increase during 1982. There is, of course, no certain way of knowing whether these frequencies represent nearly equivalent numbers of plants established annually or not, but based on the high annual survival rate of 97% for a large Missouri population (Lewis and Zenger, 1982), it is a reasonable assumption. The interesting ecolog-

Table 1. Population structure of 211 plants of *Panax quinquefolium* from Roxbury, NY.

Age	Frequency (%)	Prongs/ plant (average)	Leaflets/ plant (average)	Flowering plants (%)	Flowers/ flowering plants (average)
1	56.9	1.0	3.2	0	0
2	10.4	1.5	6.2	13.6	2.7
3	9.5	2.2	10.1	60.0	7.3
4	3.8	2.4	11.4	87.5	8.4
5	1.8	2.8	12.8	75.0	12.7
6	1.8	1.8	12.8	100	14.0
7	3.3	2.6	12.7	100	8.2*
8	2.8	3.0	15.0	100	16.7
9	1.4	2.3	12.0	100	22.5*
10	1.8	3.0	15.0	100	22.0*
11	2.4	3.0	14.8	100	15.4
12–21	3.8	3.0	15.0	87.5	20.7*

*One inflorescence broken or chewed and flower number could not be determined.

ical observations of Hu et al. (1980) involving a quadrat of 24 plants in Connecticut showed a death rate of 58.3% over an interval of seven years, but this high mortality may be biased because of small sample size.

Morphologically the population consisted of four classes based on prong and leaflet numbers (a prong consists of 3–6 palmately compound leaflets and a petiole without an axillary bud at the juncture of the aerial stem typical of leaves; most flowering plants have 2–4 prongs and an inflorescence in a whorl). One-pronged plants had 3–5 leaflets, predominantly with 3 leaflets and only infrequently 4 (0.8%) or 5 (3.3%), two-pronged plants had 6–10 leaflets, three-pronged plants had 14–16 leaflets, and the one four-pronged plant had 19 leaflets. Five leaflets per prong were most common, those with 3 or 4 occasional, and those with 6 rare among plants with two or more prongs.

Most one-pronged plants were one year old, although a few were two (9.0%) or 3 years (0.8%) of age. Two-pronged plants varied in age from 2 to 9 years, with an exceptional one being 19 years old, for an average of 3.9 years. The majority were two (26.0%), three (40.5%), or four (13.5%) years old. Three-pronged plants also varied markedly in age from 3 to 21 years. They averaged 8.6 years, but their numbers were rather constant between years 3 and 11 (minimum of 3 plants or 7.5% and maximum of 6 plants or 15.0%), and consistently very few (0 or 1) between ages 12 and 21. The single 4-pronged plant was 17 years old. There was a strong correlation between age and morphological class as measured by both prong number (r = 0.798, P<0.001) and leaflet number (r = 0.799, P<0.001), and thus the population illustrated an orderly increase in size and leaf area with age, as found in Missouri (Lewis and Zenger, 1982).

Flowering

All one-pronged plants were juveniles (nonflowering), 45.9% of two-pronged plants were also juveniles, but all three-pronged and the one four-pronged plants formed inflorescences. Of the two-pronged flowering plants, those two years old averaged 2.7 flowers (or floral buds) per plant, while older ones averaged 4 to 5 flowers depending on age. They ranged from 1–12 per plant with an overall average of 4.4 flowers. Interestingly, the 19 year old two-pronged plant had no discernable inflorescence. Flowers of three-pronged plants ranged from 5–32 with an average of 16.2 flowers per plant. The four-pronged plant had 31 flowers. There were highly significant correlations between flower numbers and morphological class (prong number r = 0.817, P<0.001, leaflet number r = 0.822, P<0.001) and also age (r = 0.724, P<0.001), as reported for populations in Missouri (Lewis and Zenger, 1982) and Wisconsin (Carpenter and Cottam, 1982). However, two-pronged plants rarely flowered in Wisconsin in contrast to those in Missouri and New York where flowering reached 55.8% and 54.1%, respectively.

Environmental Corollaries

Based on survivorship in 1982, only 15.6% of the population was established in the 15-year period from 1962 to 1976. During the subsequent five years the number of plants increased by 25.6%, a modest rise perhaps reflecting additional propagules in an aging and slowly increasing population. Not until 1982 was there a large increase in plants when 56.9% of the population was established in a single year. To explain this dramatic rise solely by small population increases and propagule accumulations seems unlikely based on the modest reproductive performance in the immediate past.

As growth and development patterns were altered markedly in a Missouri population of *P. quinquefolium* during adverse environmental conditions (Lewis and Zenger, 1982), it is of interest to compare the New York population structure during the past few years with local climatic conditions during the same period. The latter are summarized for monthly precipitation and temperature measurements in Table 2, as well as for 20-year averages. For the 5-year period prior to 1982, one striking aspect of the precipitation data

Table 2. Precipitation and temperature records for Delaware Co., NY.

	1982	1981	1980	1979	1978	1977	20-yr Mean ± S.D.
Precipitation (inches)[1]							
January	3.32	0.64	1.05	6.69	5.72	1.25	2.77 ± 1.63
February	2.21	5.78	0.95	1.56	1.20	2.65	2.41 ± 1.20
March	2.47	0.74	5.59	3.42	2.42	6.55	3.22 ± 1.31
April	2.22	3.28	3.96	3.70	1.70	3.38	3.08 ± 0.86
May	3.84	4.22	1.05	5.56	3.48	4.03	3.88 ± 1.45
June	3.89	3.53	4.74	1.27	3.59	3.02	3.94 ± 1.75
July		3.47	2.95	3.77	3.63	2.55	3.83 ± 1.39
August		3.16	4.21	2.50	5.14	5.49	3.82 ± 1.20
September		5.54	3.44	5.03	3.36	10.21	3.74 ± 2.07
October		4.30	3.17	5.22	3.95	7.32	3.28 ± 1.91
November		3.96	3.28	2.62	1.45	4.98	3.54 ± 1.37
December		1.55	1.59	2.38	3.25	4.80	3.35 ± 1.61
Total		40.15	35.97	43.69	38.88	56.22	40.87 ± 6.34
Temperature (°F)[2]							
January	14.95	14.65	24.35	22.80	20.15	13.10	20.3 ± 4.8
February	24.75	31.60	20.15	13.55	15.60	23.50	21.8 ± 4.5
March	31.25	34.60	31.90	37.35	29.55	36.70	32.8 ± 3.2
April	42.35	47.85	46.30	44.50	42.75	46.40	43.9 ± 3.5
May	57.45	56.20	57.05	57.25	55.80	57.95	55.2 ± 3.1
June	59.75	64.30	60.50	62.65	62.45	61.15	63.8 ± 2.1
July		68.40	68.60	68.75	66.70	67.95	68.4 ± 1.4
August		63.60	70.25	66.70	69.20	66.85	66.5 ± 2.3
September		59.15	61.25	58.50	58.10	60.90	59.7 ± 2.0
October		48.80	46.05	45.60	47.45	47.30	48.7 ± 3.4
November		42.90	34.80	39.05	38.75	42.00	39.0 ± 3.4
December		31.10	21.05	25.80	27.65	25.00	27.1 ± 3.3

[1]Arkville (42°08′, 74°39′, 1310 ft), Deposit (42°04′, 75°26′, 1000 ft), Downsville Dam (42°05′, 74°58′, 1300 ft), and Kortright (42°25′, 74°48′, 1720 ft).
[2]Deposit and Downsville Dam.

was the irregular monthly averages during the first part of each year. Thus, very low precipitation occurred either in January or February each year from 1977 to 1981 when much moisture would be in the form of snow. If adequate, snow would serve as an important insulation for seeds during the coldest months of the year (averages 13.1–20.2° F), but when markedly reduced, as from 1977 to 1981, this lack of cover might prove deleterious to seed viability. Also, during these years, precipitation was sometimes much lower than average in April or May when seed germination and seedling establishment would have been paramount; reduced moisture at this time would clearly hinder maximal recruitment. In 1981, for example, January precipitation totaled only 0.6 in. (20–year average 2.8 in.) during one of the coldest months in Delaware County (average 14.7° F). In 1980, the situation was even more extreme, for not only was there below average precipitation (0.95 in. versus 20–year average 2.41 in.) during the coldest month of the year (February, average 20.2° F), but May proved low in precipitation (1.05 in. versus 20-year average 3.88 in.) during an important month for germination and seedling development. For the first six months of 1982, however, monthly precipitation averages compared favorably with the 20-year averages. This presumed norm had not prevailed in Delaware County since 1974–76. That no appreciable population increase occurred during this period is perhaps explained by the fact that only 20 to 33 plants existed in the population, many being juveniles, and thus few propagules and little recruitment would have been possible even under ideal conditions.

These corollary data suggest that local environmental factors are very significant for the recruitment and survival of American ginseng populations. It is unfortunate, but because of the destruction of this important population, such a relationship cannot be tested further.

ACKNOWLEDGMENTS

I appreciate the assistance of Arthur W. Rashap, Ginseng Research Institute, and Edmund Millar, Cold Mountain Farm, both of Delaware Co., New York for locating the population and helping in the field, and the O'Connor Foundation and its Executive Secretary, Donald Bishop, Hobart, New York, for a grant-in-aid to study American ginseng in Delaware County. Special thanks go to Dr. Vincent E. Zenger, Washington University School of Medicine.

LITERATURE CITED

CARPENTER, S. G. AND G. COTTAM. 1982. Growth and reproduction of American ginseng (*Panax quinquefolium*) in Wisconsin, U.S.A. Canad. J. Bot. 60: 2692–2696.

HU, S. Y., L. RÜDENBERG, AND P. D. TREDICI. 1980. Studies of American ginsengs. Rhodora 82: 627–636.

LEWIS, W. H. AND V. E. ZENGER. 1982. Population dynamics of the American ginseng *Panax quinquefolium* (Araliaceae). Amer. J. Bot. 69: 1483–1490.

DEPARTMENT OF BIOLOGY
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI 63130