Annual Cycles of Growth and Use of Chinese Privet by White-tailed Deer in Northwestern Georgia

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Abstract: Chinese privet (*Ligustrum sinense*) is a common shrub in the southeastern United States, but no studies have examined white-tailed deer (*Odocoileus virginianus*) use of privet. We investigated the seasonality of deer use of privet browse and the effect of deer browsing on privet twig growth. We tagged and repeatedly measured about 200 privet twig clusters in forest and field-edge habitats at Chickamauga Battlefield Park (CBP) in northwestern Georgia during 2 consecutive years. Twig clusters were examined bimonthly for signs of recent browsing and measured in November, January, March, and July during both years. Deer browsing on privet was highly concentrated in the winter months when percent use reached ≥60% in both habitats. Twig cluster length was reduced during the winter browsing period by <5.0 cm and the reduction was exceeded 4- to 6-fold by regrowth. The heavy winter use of privet by deer and privet's great capacity for regrowth suggest that privet may be an important deer forage in the southeastern United States.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 50:575-582

The importance of broadleaved evergreen, semi-evergreen, and tardily deciduous shrubs and vines in the feeding ecology of white-tailed deer in the southeastern United States has been recognized for at least 25 years (Lay 1969, Harlow and Hooper 1972). These forages are heavily used in fall and winter during years of acorn scarcity

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(Harlow et al. 1975, Wentworth et al. 1990), and form an important component of deer diet during all years. For example, rosebay rhododendron (*Rhododendron maximum*) is used heavily by deer in winter in the Blue Ridge Mountain physiographic region of Georgia, Tennessee, and North Carolina (Ruff 1938, Johnson et al. 1995), whereas bigleaf gallberry (*Ilex coriacea*), gallberry (*Ilex glabra*), yaupon (*Ilex vomitoria*), and wax myrtle (*Myrica cerifera*) are important late fall and early winter deer forages in the flatwoods of Florida (Harlow and Jones 1965).

Exotic evergreen vines and shrubs are more abundant than their native counterparts in much of the Piedmont Region of the southeastern United States. Japanese honeysuckle (*Lonicera japonica*), an evergreen vine, and Chinese privet, a semi-evergreen tall shrub or small tree (Radford et al. 1964), are 2 species from Eurasia that have been promoted for wildlife and ornamental purposes. Both have become naturalized over large areas of the southeastern United States (Radford et al. 1964). They are aggressive colonizers of fragmented landscapes (Wilcove 1986) and thrive in diverse habitats, sometimes outcompeting native vegetation (Hiebert and Stubbendieck 1993). Therefore, their ecology, management, and food and cover value to wildlife are of interest to natural resource managers.

Despite evidence that Chinese privet browse and fruit are used heavily by deer during winter in the Piedmont and Ridge and Valley provinces of Georgia, no studies have documented the seasonality and extent of deer browsing on privet or the effect of deer herbivory on privet growth. A preliminary winter browse survey conducted on Chickamauga Battlefield Park (CBP), Georgia, in 1992 indicated a browsing intensity of ≥60% on privet twigs (Stromayer et al. 1994). We designed this study to characterize seasonal use of privet browse and to quantify use and regrowth of privet twig clusters.

Methods

Fieldwork was conducted on the 2,138-ha CBP portion of the Chickamauga and Chattanooga National Military Park in Catoosa and Walker counties in extreme northwestern Georgia. The park lies in a broad valley in the Ridge and Valley Province of Georgia. Elevation ranges from 109 to 229 m (Van Horn 1981). Mean annual temperature is 15.4 C and precipitation averages 133.6 cm per annum (Chattanooga Weather Sta., U.S. Natl. Oceanic and Atmos. Admin. pers. commun.). The park is >90% forest and about 9% mown fields (Van Horn 1981).

The park has a history of human disturbance since the 1820s, when settlers cleared portions of the forest for farms (Van Horn 1981). The current overstory at CBP is dominated by pines (*Pinus* spp.), oaks (*Quercus* spp.), and hickories (*Carya* spp.), whereas the shrub class is dominated by Chinese privet with some dogwood (*Cornus florida*), hickories, elms (*Ulmus* spp.), and eastern redcedar (*Juniperus virginiana*) (Rogers et al. 1993). Tucker (1996) estimated deer densities to be 30–70/km^2 at CBP, and suggested that roadkills, poaching, and deer hunting adjacent to the park may limit growth of the CBP deer herd, thus preventing it from exceeding ecological carrying capacity.

Privet-rich habitats on CBP (approximately 40% of the park area) were stratified into forest and field-edge categories. Transect starting points were chosen randomly in these sites. Transects were ≥60 m long. Plants were marked at ≥3-m intervals with numbered 40-cm sections of PVC pipe driven into the ground. Transects were continued until 20 plants had been marked or until no additional plants were found. Forest transects were aligned with compass bearings starting ≥3 m from and perpendicular to habitat edges. Field-edge transects followed the well-defined boundaries between mowed fields and associated privet hedges. Five transects were placed in the forest habitat and 4 transects were placed in the field-edge habitat each year.

Winter browse studies generally define the experimental unit as that portion of a branch developed during the last growing season (Stickney 1966). With privet, it is often difficult to distinguish between old and current year growth. Thus, we defined the experimental unit as the lateral branch or twig cluster (Wikeem and Pitt 1987), but considered all lateral branches as twig clusters regardless of age. We chose November as the beginning of the "privet year" because although stem elongation generally ceased by August, browsing in early fall elicited regrowth into October.

The lateral twig cluster closest to the transect line in each of 3 height classes (0–40 cm, 40–80 cm, and 80–120 cm) was chosen for each plant. Each was marked with a numbered aluminum tag. A piece of red nylon thread was tied around the most distal 25 cm of the twig cluster (or to its base if the total length of the longest individual twig in the cluster was ≤25 cm long) to serve as a reproducible starting point for measurements. Because not all height classes were available on every plant, a total of 194 and 213 twig clusters were marked in forest and field-edge habitats, respectively, in 1992, and 231 and 211 in 1993. Starting in November 1992, we determined percent use of privet browse during 2 annual cycles with bimonthly browse surveys of marked privet twig clusters. We estimated twig cluster length reduction (TCLR) and regrowth by repeated measurements of marked privet twig clusters in November, January, March, and July during both years.

We defined percent use of privet as browsed clusters/available clusters × 100 (Wikeem and Pitt 1987). To determine the seasonality of deer use, twig clusters were examined for evidence of recent browsing bimonthly starting in November. Recent browsing was defined as browsing sign that occurred within the last 2 months. Thus, the percent use index was non-cumulative between sampling periods. To determine the timing and extent of TCLR caused by deer during the non-growing season, the total aggregate length of all subunits of each twig cluster was determined in November, January, and March. Twig clusters were measured again in late July to determine regrowth capacity following known levels of TCLR. Five descriptive variables or statistics were calculated for each marked twig cluster: TCLR (Nov-Jan) was defined as the difference in aggregate twig cluster length between November and January. TCLR (Jan-Mar) was defined as the difference in aggregate twig cluster length between January and March. USE (TCLR Nov-Mar) was defined as the difference in aggregate twig cluster length between November and March. REGROWTH (Jul-Mar) was defined as the difference in aggregate twig cluster length between July and March. DIFFERENCE was defined as the difference between REGROWTH and USE.

Percent use was calculated by height class and transect, thus yielding 3 (height classes) × 4 (transects) = 12 estimates of percent use per bimonthly sampling period for the field-edge habitat and 3 × 5 = 15 estimates of percent use per bimonthly sampling period for the forest habitat. Percent use data were arcsine square-root transformed (Sokal and Rohlf 1969, Ott 1988) and a 2-way analysis of variance (habitat by sampling period) with sampling period as a repeated measure was used to test for effects of habitat and sampling period on percent use (Cody and Smith 1991). When significant habitat-by-sampling period interactions occurred, differences in percent use between habitats within bimonthly sampling periods were analyzed with t-tests (SAS Inst.1990).

Data on TCLR (Nov-Jan), TCLR (Jan-Mar), USE, and REGROWTH were analyzed using a 2-way analysis of variance design (SAS Inst. 1990) to determine effects of height class, habitat and the height-by-habitat interaction. To determine if USE differed from REGROWTH on a twig cluster specific basis, USE and REGROWTH data by habitat type and year were compared with paired *t*-tests (SAS Inst. 1990). Paired *t*-tests were not used to compare TCLR (Nov-Jan) to TCLR (Jan-Mar) because these samples were not independent. Linear regression (SAS Inst. 1990) of REGROWTH on USE by habitat type and year was performed to determine if USE could predict REGROWTH. Because new transects were set out yearly, a comparison of year effects was confounded with differences between transect locations; therefore, no between-year comparisons were made.

Results

Percent Use

Percent use of privet peaked in the period from January to March during both years, when about 60% of the marked twig clusters were browsed in both habitats (Table 1). Percent use was lowest in the period from May to July when <10% of available twig clusters showed signs of recent use (Table 1). During 1992–93, percent use differed by sampling period and habitat, but not the habitat-by-sampling period interaction (Table 1). During 1993–94, percent use varied by the habitat-by-sampling period interaction term. Because of the significant habitat-by-sampling period interaction in 1993–95, differences between habitats were tested by separate *t*-tests within sampling periods. These tests revealed that percent use was greater in the forest than the field-edge habitat in November ($P = 0.049$), January ($P < 0.05$), and September ($P < 0.002$), but did not differ in the remaining 3 sampling periods (Table 1).

Use and Regrowth

Mean USE was ≤46.7 ± 4.6 mm in both years and habitats (Table 2). REGROWTH data indicated that the same twig cluster regrew 4- to 6-fold greater than USE (Table 2). TCLR varied by habitat in the November-January 1992–93 ($F = 18.41$; $df = 1, 410$; $P < 0.001$), January-March 1994 ($F = 6.93$; $df = 1, 409$; $P < 0.009$), and November-March 1992–93 ($F = 11.76$; $df = 1, 412$; $P < 0.001$) sampling periods

Table 1. Noncumulative percent use for marked privet twig clusters within 2 different habitats[a] during 6 seasonal sampling periods[a] for 2 years on Chickamauga Battlefield Park, Georgia.

			November		January		March		May		July		September	
Year	Habitat	*N*[b]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
1992–93	Forest	15	20.02	5.1	61.3	5.3	60.9	4.5	1.4	1.0	0.9	0.9	7.0	2.4
	Field[c]	12	36.8	6.5	73.3	3.6	58.5	4.7	1.4	0.7	3.7	1.4	12.4	3.4
1993–94	Forest	15	21.1*[d]	4.5	74.2*	3.8	52.6	4.3	6.3	2.0	3.3	1.1	20.5*	3.3
	Field	12	7.9*	2.0	63.2*	3.8	48.5	5.3	9.8	3.6	2.9	1.3	6.3*	2.5

[a]During 1992–93, percent use was affected only by sampling period (F = 110.4; df = 5, 125; $P < 0.001$) and habitat (F = 8.59; df = 1, 25; $P < 0.007$); during 1993–94, percent use was affected by the habitat-by-sampling period interaction term (F = 2.62; df = 5, 125; $P < 0.027$).

[b]N = number of transects (5 in forest, 4 in field-edge) x height classes (3/plant).

[c]Field-edge.

[d]* = for 1993–94, means within sampling periods differ significantly ($P < 0.05$) between habitats (tested by separate *t*-tests within sampling periods because of the significant habitat-by-sampling period interaction term).

Table 2. TCLR (Twig Cluster Length Reduction), USE, REGROWTH, and DIFFERENCE data (mm) for marked privet twig clusters during 2 November through July cycles in 2 habitats on Chickamauga Battlefield Park, Georgia.

		TCLR														
		Nov—Jan[a]			Jan—Mar[a]			USE[a,b]			REGROWTH[a]			DIFFERENCE[c]		
Year	Habitat	*N*	Mean	SE	*N*	Mean	SE	*N*	Mean	SE	*N*	Mean	SE	*N*	Mean	SE
1992–93	Forest	194	9.4a	3.3	191	16.4a	3.1	194	25.7a	4.0	155	104.6a	14.5	155	81.7*	14.3
	Field[d]	222	29.2b	3.2	219	17.9a	3.7	222	46.7b	4.6	188	277.2b	27.4	188	231.5*	27.4
1993–94	Forest	225	29.1a	3.3	221	13.5a	2.1	226	41.3a	3.3	190	196.9a	29.0	184	132.9*	23.8
	Field	200	32.1a	4.7	194	4.9b	2.3	197	39.1a	5.2	174	275.7a	29.4	173	232.2*	29.4

[a]Means within columns and years followed by different letters differ significantly ($P < 0.05$) between habitats (F - test).

[b]USE = twig cluster length in November minus twig cluster length in March.

[c]Means within rows followed by an asterisk indicate significant ($P < 0.05$) differences between mean USE and mean REGROWTH (paired *t*-test).

[d]Field-edge.

(Table 2). Habitat, height class, and their interaction did not differ ($P > 0.05$) in other sampling periods.

REGROWTH varied by habitat (F = 23.58; df = 1, 337; $P < 0.001$) in 1992–93 (Table 2) and by height class (F = 13.98; df = 2, 358; $P = 0.001$) in 1993–94. All other main and interaction effects were nonsignificant ($P > 0.05$). Paired *t*-tests revealed that REGROWTH was greater than USE in both years and habitat types ($P < 0.001$) for each test (Table 2). Significant ($P < 0.05$) linear regressions between REGROWTH (R) and USE (U) occurred only for the forest data in 1993 ($R = 0.63U + 90.1$, $R^2 = 0.038$, $P = 0.015$).

Discussion

Percent use of privet browse by deer at CBP was highly seasonal, showing a strong peak in winter in both years. Deer at CBP browsed a high proportion of available privet twig clusters each winter but probably only a small fraction of current year's growth (as REGROWTH exceeded USE by ≥400% in both years and habitat types). These patterns suggest that the browsing intensity we observed was far below the maximum sustainable level. Schierenbeck et al. (1994) showed that Japanese honeysuckle in the southeastern United States produced less growth when herbivory was absent, suggesting that compensatory or overcompensatory growth in response to herbivory may be an important factor in the ecology of this species. If privet exhibits a similar response to herbivory, then privet twig growth might be expected to increase as deer browsing intensity increased up to some optimum level. Our regression of REGROWTH on USE suggests that, at current levels of privet forage utilization, REGROWTH is relatively independent of USE. Thus, factors such as rainfall, soil fertility, and light may be more important than deer herbivory in explaining privet regrowth at CBP.

Stickney (1966) observed that when a high percentage of available twigs are browsed, percent use may correlate poorly with percent twig length reduction. Because our data showed that most privet twig clusters at CBP were browsed at least once each winter, we believe that directly measuring USE and REGROWTH is the most biologically meaningful way to assess the relationship of the CBP deer herd to the privet forage resource. We suggest that privet may continue to expand its foliar volume at CBP because although most twig clusters are browsed at least once during the winter browsing period, only a small fraction of annual growth is removed. This finding is analogous to what Strole and Anderson (1992) reported concerning multiflora rose (*Rosa multiflora*); despite heavy percent use, it increased on their study sites.

Most techniques to assess deer use of winter browse were developed in the northern United States and Canada, where long dormant seasons facilitate the study of deer use of browse species (Aldous 1944). In the southeastern region, researchers are challenged by long growing seasons that overlap with periods of use. Also, twig cluster length reduction may underestimate deer browsing impacts on privet, because deer may glean leaves from privet stems without reducing twig length. In addition, the tendency for privet to branch repeatedly and hedge when browsed makes the repeated measurement of twig clusters to assess USE and REGROWTH difficult. Despite these potential sources of error, the highly seasonal use of privet browse by deer at CBP facilitated our research effort.

We expected field-edge privet to be browsed more heavily than forest privet because deer at CBP appear to use fields out of proportion to their availability during the winter months. In addition, we speculated that field-edge privet would have higher crude protein (CP) levels than forest privet, which might result in preferential use of the former. We found that deer did use field-edge privet more heavily the first year, but this pattern was not consistent the second year. Given that new transects were set out each year, a comparison of habitat effects between years is confounded by location effects. Also, our related studies of CP levels in privet (Stromayer et al. 1996) revealed that CP was higher in forest versus field-edge privet throughout the year. Thus, our current understanding of privet-deer interactions at CBP provides no likely explanation for the differing habitat effects that we observed between the first and second years of the study.

Based on widely-used nutritional indices, Tucker (1996) reported that CBP deer herd health was in the good to excellent range. This evidence, coupled with high CP levels (> 12%) in privet browse year-round (Stromayer et al. 1996) and the absence of a browse line at CBP, suggests that the high percent use of privet browse by deer at CBP was not a case of a nutritionally stressed deer herd utilizing an emergency food. Instead, we suggest that privet is a valuable winter forage resource for CBP deer. Studies of browsing intensity cannot replace more comprehensive investigations of food habits (Harlow 1979). However, this study is a logical first step in describing the value of privet browse to deer.

The role of privet as a winter deer browse has been overlooked. We suggest that privet is an important deer forage in the southeastern United States. The heavy winter percent use of privet browse by deer at CBP and the excellent condition of CBP deer indicate that privet may increase the carrying capacity at CBP and probably on other deer ranges in the southeastern U.S. Because privet is an exotic species that may outcompete native forages, we recommend that it be managed as a winter deer forage only where it is already naturalized. Planting privet in areas where it is not established probably is inadvisable as a habitat management recommendation.

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