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Spatial use of warm-season food plots by white-tailed deer

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Abstract

White-tailed deer (*Odocoileus virginianus* Zimm.) appear to concentrate foraging activity along the perimeters of warm-season food plots. Because of this, we tested the hypothesis that (1) providing travel lanes (i.e., rows not planted) free of vegetation within food plots will increase deer use of the plots and result in an equal spatial distribution of forage use within the plots, and (2) skip-row planting will result in increased yield and survival of lablab (*Dolichos lablab* L.), an annual legume. During 1994 and 1995, lablab was established by planting (1) every row spaced 0.9 m apart (solid), (2) 2 rows and not planting 1 row (skip 1), and (3) 2 rows and not planting 2 rows (skip 2) in two 5-ha food plots. Planting scheme did not affect spatial patterns of food plot use by deer. Utilization was concentrated at food plot perimeters on 9 of 15 sampling dates. Food plot utilization by deer was greater in skip 2 treatments only during August 1995, possibly as a result of greater forage availability resulting from greater plant survival than solid rows. Deer foraging in food plots apparently shifted foraging activities to an area of greater forage availability as the resource supply was depleted. Skip-row planting had lower overall planting costs/ha than solid planting but maintained similar forage production per hectare.

Resumen

El venado cola blanca (*Odocoileus virginianus* Zimm.) parece ser que concentra su actividad forrajera a lo largo de perimetros de parcelas alimenticias durante las estaciones de alta temperatura ambiental. Por lo cual, nosotros analisámos esta hipótesis (1) proporcionar lineas de recorrido (i.e., filas no plantadas) libres de vegetación adentro de las parcelas a su causa se aumentar en el uso con una misma distribución espacial del uso del forrage, y (2) sembrar lineas alternas teniendo como resultado un incremento en la cosecha y sobrevivencia de lablab (*Dolichos lablab* L.), una leguminosa anual. Durante 1994 y 1995, lablab fué establecida abase de plantación (1) con un espacio entre lineas de 0.9m (sólido), (2) plantando 2 lineas y no plantando 1 linea (saltando 1), y (3) plantando 2 lineas y no plantando 2 lineas (saltando 2) en dos parcelas alimenticias de 5-ha. El esquema de plantación no afectó a los venados en sus patrones espaciales en el uso de las parcelas alimenticias. La utilización dentro de los perímetros de las parcelas de alimentación se concentró en 9 de las 15 fechas de muestreo. La utilización adentro de las parcelas alimenticias por los venados fue mayor en el tratamiento saltando 2 líneas solamente durante agosto de 1995, posiblemente esto es el resultado de la gran sobrevivencia de plantas en estas lineas solidas. La actividad de forrajeo de venados en las parcelas alimenticias aparentemente cambió aáreas de mayor disponibilidad de forraje cuando el recurso fu agotado. Las plantaciones de lineas alternadas tuvieron un menor costo de plantación/ha que las plantaciones sólidas pero ambas mantuvieron una producción similar de forraje/ha.

Key Words: *Dolichos lablab* L., edge, lablab, *Odocoileus virginianus* Zimm., skip-row planting, southern Texas

Planting warm-season food plots is a common management practice to increase forage for white-tailed deer (*Odocoileus virginianus* Zimm.) throughout the southeastern United States. Adams et al. (1992) reported that 23% of landowners in Texas who lease hunting rights plant food plots as a management technique. In Mississippi, Vanderhoof and Jacobson (1989) found that maintaining 0.5% of an area in agronomic food plots year-round increased body mass, number of antler points, beam circumferences, and beam lengths of white-tailed deer. Additionally, Johnson et al. (1987) documented a 19% increase in live weights of yearling male white-tailed deer after establishment of cool-season food plots. Both of these studies were conducted in relatively mesic habitats. In semi-arid habitats, low rainfall could be a limiting factor to deer nutrition and food plot success.

The nutritional value of natural forage species in the southeastern United States varies seasonally and is often low during summer (Varner et al. 1977, Jacobson 1994). Meyer et al. (1984) proposed that reduced crude protein and energy levels in deer diets during summer may decrease fawn survival. Food plots could be a management tool to increase availability of nutritious forage for white-tailed deer during summer. Feather and Fulbright (1995) reported that warm-season forages did not persist through August in semi-arid southern Texas.

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Mozingo (1984) reported that skip-row planting produced greater yields on a planted hectare basis than did planting all rows (solid planting) because of more efficient use of moisture and light by the plants. Research on the effects of row width on yields of warm-season crop plants that are also grown in food plots for deer has focused on seed yield rather than forage yield (Mozingo 1984, Weaver et al. 1991).

In previous research on summer food plots planted in 'Rongai' lablab (*Dolichos lablab* L.), deer tended to forage at the perimeter of plots from April to June rather than foraging within the plots as they did from July to October (Hehman 1995). Vegetation was dense during early summer because lablab grew across rows, which possibly obstructed access to the interior of the plots. Uniform grazing in stands of cultivated forages is desirable because ungrazed plants become mature, fibrous, and less palatable, whereas plants that are too heavily grazed lose vigor or die (Vallentine 1990). Our first objective was to test the hypothesis that food plots which provide travel lanes free of vegetation will increase intensity of deer use and more equally distribute use within the plots. Based on this hypothesis, we predicted that (1) foraging will be greater in plots with skip-row planting schemes than in plots with solid planting schemes, and (2) if food plots are planted with skip-rows, deer will forage in the interior of the plots in equal proportion to the perimeter. An alternative hypothesis was forage use by deer should be greater at the perimeter of the plots regardless of planting scheme. A second objective was to test the hypothesis that skip-row planting results in greater plant survival and yield of lablab forage than solid planting.

Materials and Methods

Study Area

Research was conducted on El Tecomate Ranch in Starr County, Tex., (98˚48'N, 26˚42'W). The climate is warm-temperate, subtropical with mild winters and only a short humid period in summer when daily maximum temperature averages 38 C. Average (1931-1962) yearly precipitation is 440 mm with peaks in June and October (Soil Conserv. Serv. 1972) (Table 1).

The study sites had McAllen fine sandy loam (fine-loamy, mixed, hyperthermic Typic Ustochrept) and Ramadero loam (fine-loamy, mixed, hyperthermic Pachic Argiustoll) soils (Soil Conserv. Serv. 1972). Vegetation on the ranch is a honey mesquite (*Prosopis glandulosa* Torr.) mixed brush community forming a continuous shrubland. Primary woody species include honey mesquite, cenizo (*Leucophyllum frutescens* (Berl.) I. M. Johnst. C.), blackbrush acacia (*Acacia rigidula* Benth.), and granjeno (*Celtis pallida* Torr.) interspersed with prickly pear cactus (*Opuntia lindheimeri* Engelm.).

Deer densities within the study area were estimated as 11 adult deer km^{-2} in October 1994 and 9 adult deer km^{-2} in October 1995 by counts from a helicopter. Aerial counts of white-tailed deer in south Texas underestimate total numbers because dense brush limits visibility (DeYoung 1985).

Food Plot Establishment

Two 5-ha food plots about 1.6 km apart with dimensions of 250 x 210 m (plot 1) and 310 x 180 m (plot 2) were used. Each plot was surrounded by a 3.2-m high fence designed to exclude deer. Once plants reached about 25 cm tall, the upper 1.6 m of the fence was lowered to allow deer entry into the plots. In 1994, plots were planted on 5 March, and the high fence was not lowered until 8 weeks later on 29 April because of low rainfall (Table 1) and slow plant growth. In 1995, plots were planted on 12 March, and the high fence was lowered 5.5 weeks later on 19 April.

'Rongai' lablab was planted in a randomized, complete-block design. Lablab was planted because it is drought tolerant and palatable to white-tailed deer (Beals et al. 1993, Feather and Fulbright 1995). The 2 food plots each contained 3 blocks (replications). Each of the 6 blocks was partitioned into 3 experimental units (food plot 1: 210 ✕ 27 m; food plot 2: 180 ✕ 27 m). Three planting schemes were randomly assigned to the 3 experimental units, with each experimental unit receiving a different planting scheme. The 3 planting schemes were (1) plant every row; (2) plant 2 rows and skip (not plant) 1 row; and (3) plant 2 rows and skip 2 rows. Each planting scheme contained 30 rows spaced 0.9 m apart. Seeding rates were 17 kg ha^{-1}, 11 kg ha^{-1}, and 8.5 kg ha^{-1} for planting schemes 1, 2, and 3, respectively (1 seed every 15 cm of row). The plots were planted with a John Deere® Maxemerge 6-row planter pulled by a John Deere® 2955 tractor. Plots were treated with Treflan (DowElanco, Indianapolis, In.) in

Table 1. Monthly precipitation (mm) for 2 food plots on El Tecomate ranch, Starr County, Texas (Jan 1994–Oct 1995) and long-term (LT) (1931–62) monthly mean rainfall (mm) collected by the Soil Conservation Service (1972) at Rio Grande City, Starr County, Tex.

	1994		1995		LT
Date	Plot 1	Plot 2	Plot 1	Plot 2	Mean
	-mm-				
Jan.	36	30	15	15	17
Feb.	0	0	0	0	24
Mar.	13	15	66	64	20
Apr.	8	20	0	0	22
May	25	25	66	66	32
Jun.	17	168	41	38	53
Jul.	8	10	20	18	51
Aug.	28	20	25	25	35
Sep.	97	58	150	145	43
Oct.	33	38	10	10	80
Nov.	0	0	—	—	47
Dec.	2	22	—	—	15
Total	438	406	393	381	439

Table 2. Mean (± SE%, n = 6) grazed lablab plants within each of 3 planting schemes for 15 sampling dates on El Tecomate ranch, Starr County, Tex., 1994–95 (May–Aug).

Date	Solid X±SE	Skip 1 X±SE	Skip 2 X±SE
	(%)		
1994			
May 11	53±5.1a[1]	49±6.9a	49±5.4a
May 26	88±3.3a	89±2.8a	87±2.9a
Jul 14	12±5.1a	12±4.8a	12±4.0a
Jul 27	28±6.9a	27±6.5a	33±7.0a
Aug 10	47±5.9a	46±7.4a	54±6.2a
Aug 24	73±5.8a	72±7.1a	80±5.9a
1995			
May 5	13±3.7a	32±7.6a	22±5.1a
May 18	27±6.5a	50±11.4a	46±8.6a
Jun 1	44±7.7a	60±11.2a	60±8.8a
Jun 15	30±6.1a	39±9.2a	30±7.1a
Jun 29	30±7.0a	31±8.3a	25±5.7a
Jul 13	28±6.4a	34±8.4a	22±5.9a
Jul 27	33±6.7a	42±9.3a	31±6.6a
Aug 10	69±7.6a	74±7.6a	71±5.4a
Aug 24	89±3.2a	97±1.2b	96±1.6b

[1]Means within a row sharing the same letter were not significantly (Tukey's HSD, P > 0.05) different.

February at 1 liter ha^{-1} and periodically cultivated as necessary for weed control. Fertilizer (N-P-K at 5-34-4; Texag, Mission, Texas) was applied to the soil in a foliar spray in early May at 190 liters ha^{-1}.

Spatial Patterns of Food Plot Use

Spatial patterns of food plot use were determined by ocular estimation with a modification of the methods described by Andren and Angelstam (1993). Our methods differed from Andren and Angelstam (1993) in that we classed plants only as grazed or ungrazed rather than using 4 grazing intensity classes. This method was employed to test our predictions of greater foraging in skip-row plots and proportional use of perimeters and interiors in skip-row plots compared to solid-planted plots. Four of the 30 rows in each planting scheme were randomly selected. At 3-m intervals along each row, the nearest plant was recorded as grazed or ungrazed. If there was not a living plant at each 3-m interval, that interval was recorded as a mortality, which provided an estimate of plant survival. Therefore, in this paper, survival was defined as at least 1 living plant within each 1 m of row at each interval, and mortality was defined as no living plants for each 1 m of row at each interval. The proportion of grazed plants was calculated for food plot location (perimeter and interior) within each planting scheme/block combination. Perimeter was defined as the outer portion of each plot up to 1/4 of the plot length (0-53 and 0-45 m for plots 1 and 2, respectively), and interior was defined as the central half of the plots. Data were analyzed by comparing proportions of grazed plants in relation to location and planting scheme. Sampling was conducted at 2-week intervals from April through August. Three sampling dates during June and July 1994 were missed because plants were heavily defoliated by grazing, and the landowner raised the fence for 1 month to prevent deer access to the plots.

Forage Standing Crop

Forage standing crop within enclosures was estimated during 1994 and 1995 by centering three, 2.8-m diameter circular wire enclosures on 3 randomly selected rows within each planting scheme in each of the 6 blocks. Sample size adequacy was calculated with equations of Bonham (1989:67) to estimate standing crop means in a treatment within 20% of the population mean at the 95% confidence level. All plant material within a 0.9-m^2 quadrat inside each wire enclosure was clipped to ground level and dried at 40 C to a constant mass. Plots were harvested during late June and late August.

Forage standing crop in the presence of grazing (forage availability) was estimated concurrently with monitoring food plot use by double sampling (Bonham 1989:202–205). Eighteen, 0.9-m^2 quadrats were placed at 10- and 8-m intervals for food plots 1 and 2, respectively. A row within each planting scheme was randomly selected for sampling at each interval. Biomass of vegetation was ocularly estimated in 18 quadrats and clipped in 9. The 2:1 ratio of estimated to clipped plots was selected based on equations of Bonham (1989:204). Plant material was weighed in the field, and 3 subsamples per replication were dried at 40° C to adjust for plant water content. Sampling was conducted monthly from late May to late August.

Statistical Analyses

We used analysis of variance for a split-block experimental design (PROC ANOVA; SAS 1988) for each sampling date with planting scheme as the whole-plot treatment in a randomized, complete block design with 6 blocks (replications) and location (perimeter or interior) as the sub-plot treatment to detect significant (P < 0.05) differences in mean percentages of grazed plants. A split-block design is a variation of the split-plot design in which the levels of 1 treatment factor (in our case, planting scheme) are randomly assigned to plots in a randomized, complete block design (Kuehl 1984). Tukey's HSD test was used as a mean separation procedure (P < 0.05). Each sampling date was analyzed separately because of missing sampling dates during 1994.

We used repeated measures analysis of variance (PROC ANOVA; SAS 1988) for a randomized, complete-block design with forage standing crop within enclosures and $\log_{10}$ transformed monthly forage availability as dependent variables to test for significant (P < 0.05) planting scheme and sampling date main effects and interactions. Biomass data were $\log_{10}$ transformed because biomass data tend to follow a lognormal distribution

Table 3. Mean (± SE%, n = 6) (averaged across 3 planting schemes) grazed lablab plants relative to food plot perimeter and interior for each sampling date on El Tecomate ranch, Starr County, Tex., 1994–95 (May–Aug).

Date[1]	Perimeter X±SE	Interior X±SE
	(%)	
1994		
May 11	57±3.9a	43±5.0b
May 26	88±2.4a	88±2.5a
Jul 14	19±4.4a	6±1.9a
Jul 27	38±5.9a	21±4.1a
Aug 10	54±5.4a	44±4.9a
Aug 24	75±4.8a	75±5.4a
1995		
May 5	32±4.0a	12±4.6b
May 18	56±5.8a	26±7.5b
Jun 1	74±4.8a	36±7.5b
Jun 15	50±3.9a	16±5.3b
Jun 29	45±4.1a	11±3.9b
Jul 13	45±4.4a	11±3.5b
Jul 27	55±4.0a	16±4.4b
Aug 10	85±2.4a	58±5.9b
Aug 24	96±1.8a	92±1.9a

[1]Planting scheme X location interaction was not significant (P > 0.05) for each sampling date.
[2]Pairs of means within a row sharing the same letter were not significantly (P > 0.05) different.

(Zar 1984, Bonham 1989:84). The sampling date by planting scheme interaction for monthly forage availability was significant ($P = 0.01$); therefore, these data were analyzed by sampling date. Tukey's HSD test was used to separate significant ($P < 0.05$) main effect means. All differences discussed are statistically significant at the 5% level unless otherwise specified.

Results

Spatial Patterns and Intensity of Deer Foraging

The proportion of grazed plants was greater in skip 1 or skip 2 planting schemes than in solid row plantings on 24 August 1995 (Table 2). There were no significant differences in proportion of grazed plants among planting schemes on other sampling dates.

The planting scheme by location (perimeter vs. interior) interaction for percent grazed plants was not significant for any of the 15 sampling dates. Averaged across planting schemes, the proportion of grazed plants during 1994 was greater in plot perimeters than in interiors only during 11 May (Table 3). During 1995, the proportion grazed plants was greater in plot perimeters than in interiors during 8 of 9 sampling dates, indicating that deer concentrated foraging efforts at plot perimeters throughout most of the year.

Forage Standing Crop and Availability

Averaged across sampling dates, mean ($n = 6$) forage standing crop within enclosures did not differ among planting schemes with solid, skip 1, and skip 2 averaging 852 ± 111, 916 ± 114, and 815 ± 99 kg/ha (X ± SE). However, mean ($n = 6$) forage availability was greater in skip 2 than in solid plantings in August 1994 and was greater in both skip 1 and skip 2 than in solid plantings in August 1995 (Table 4).

The skip 2 planting scheme had greater plant survival than did solid rows from 27 July through 24 August 1994, and during 10 and 24 August 1995 (Table 5). The skip 1 planting scheme had greater plant survival than the skip 2 scheme on 13 July and the solid scheme during 27 July through 24 August 1995.

Discussion and Conclusions

Spatial Patterns of Deer Foraging

Planting in skip-rows did not increase foraging by deer compared to solid-rows, except during 24 August 1995. More foraging occurred in skip-row plantings during 24 August 1995 possibly because forage availability was greater in the skip-row planting schemes, resulting from greater plant survival. This is supported by the greater proportion of grazed plants in skip-row planting schemes than in solid rows on 24 August 1995. There were fewer surviving plants in solid rows, and if deer foraging was proportionately distributed among planting schemes, the proportion of grazed plants should have been lower in skip-row plantings because there were more plants from which to choose. Deer apparently fed in skip-rows during August 1995 because of greater forage availability and not as a result of travel lanes furnished by the skip-rows.

Skip-row planting did not result in even spatial distribution of deer foraging among food plot perimeters and interiors. The concentration of foraging efforts at plot perimeters throughout most of 1995 indicates an "edge effect" similar to that reported for black-tailed deer (*Odocoileus hemionus columbianus* Raf.) (Hanley 1983) and for medium and large ungulates feeding at the edge of 0.15- to 1.3-ha glades within Acacia bushland in Kenya (Young et al. 1995). However, in our study deer did not consistently restrict foraging activity to food plot edges, e.g., 26 May through 24 August 1994 and August 1995 when deer use did not differ between plot edges and interiors.

Deer utilized food plots in our study area primarily at night and spent diurnal hours in the adjacent, dense shrubland that surrounded each of the plots (Bonner 1996). Dense brush, which

Table 4. Mean (± SE kg/ha, n = 6) lablab forage availability within each of 3 planting schemes for each sampling date on El Tecomate ranch, Starr County, Texx, 1994–95 (May–Aug).

Date	Solid X±SE	Skip 1 X±SE	Skip 2 X±SE
		(kg/ha)	
1994			
May	147±14a[1]	96±110a	82±11a
Jun	475±41a	368±36a	275±31a
Jul	382±46a	323±41a	394±42a
Aug	211±38b	251±50ab	279±37a
1995			
May	772±60a	831±59a	841±59a
Jun	1,532±119a	1,457±94a	1,649±116a
Jul	743±57a	1,099±99a	1,018±76a
Aug	27±13b	190±35a	346±36a

[1]Means within a row sharing the same letter were not significantly (Tukey's HSD, P > 0.05) different.

Table 5. Mean (± SE%, n = 6) lablab plant survival within each of 3 planting schemes for each-sampling date on El Tecomate ranch, Starr County, Tex., 1994-95 (May–Aug).

Date	Solid X±SE	Skip 1 X±SE	Skip 2 X±SE
	(%)		
1994			
May 11	91±1.9a[1]	96±0.7a	91±1.3a
May 26	90±2.0a	95±1.3a	90±1.6a
Jul 14	87±2.4a	91±1.7a	92±1.1a
Jul 27	78±2.2b	88±2.0ab	92±1.1a
Aug 10	60±3.2b	72±2.6ab	84±1.4a
Aug 24	53±3.5b	68±2.7ab	81±1.8a
1995			
May 5	100±0.3a	100±0.3a	100±0.5a
May 18	100±0.3a	100±0.4a	100±0.4a
Jun 1	100±0.2a	100±0.3a	100±0.3a
Jun 15	97±0.5a	97±0.6a	97±0.4a
Jun 29	96±0.6a	97±0.4a	98±0.4a
Jul 13	95±0.5ab	96±0.4a	94±0.7b
Jul 27	86±1.4b	92±0.8a	88±1.4ab
Aug 10	32±2.5b	66±2.3a	77±2.0a
Aug 24	21±2.0b	61±2.5a	71±2.1a

[1]Means in a row sharing the same letter were not significantly (Tukey's HSD, P > 0.05) different.

surrounded our food plots, is used for bedding by deer diurnally, whereas openings dominated by herbaceous vegetation are the center of crepuscular and nocturnal feeding activity (Inglis et al. 1986). During 1995, deer traveling from the shrubland into the plots were confronted with abundant forage at plot edges, and further travel into the plots to obtain forage was unnecessary during most of the summer. However, when forage supply was depleted in plot edges, deer began foraging in plot interiors. Williamson and Hirth (1985) found similar foraging strategies in that deer preferred to feed along clear-cut edges, but they foraged in clear-cut interiors when an abundance of preferred browse was present.

"Edge effects" were not evident during 1994 in which 11 May was the only date showing significant differences in proportion of grazed plants between edge and interior. Deer use of food plot perimeters and interiors was similar during 14 July 1994 possibly because few deer were using the food plots during this time. However, because forage availability during 1994 was low, compared to 1995, deer traveled further into the plots throughout the rest of the year.

When forage was abundant at the perimeter of the plots, deer were able to satisfy nutritional needs while remaining in close proximity to the dense brush outside the plots. Forages eaten by white-tailed deer in south Texas during summer are energy deficient (Meyer et al. 1984). Deer possibly restricted foraging activity to the perimeter of food plots during 1995 to minimize the energy expenditures resulting from travel into the plots.

Once forage in the perimeter of the plots was depleted, they foraged in the interior. Foragers remain in a patch until forage is depleted below some threshold and the time spent in a patch by a forager will be proportional to relative food availability (Senft et al. 1987). Possibly, when forage in the perimeter of the food plots was depleted below some critical threshold it was more energetically efficient for deer to begin feeding in the interior of the food plots. In August 1995, deer focused foraging activity on skip-row plantings possibly because forage availability and, subsequently, intake rate in the solid plantings had fallen below some critical threshold.

A second hypothesis is that deer foraged at the perimeter of the plots to remain near the "escape cover" provided by the dense brush adjacent to the plots (Stephens and Krebs 1986). Energy status and proximity to escape cover could interact to influence foraging patterns of deer in food plots. For example, yellow-eyed juncos (*Junco phaenotus* Wagler) with positive energy budgets were risk averse, whereas those with negative energy budgets were risk prone (Stephens and Krebs 1986). Designing food plots to maximize perimeter and minimize interior, e.g., rectangular-shaped plots rather than square ones, would minimize the amount of travel into the plots and provide greater proximity of escape cover to foraging areas.

Forage Standing Crop and Availability

Both skip 1 and 2 skip rows maintained similar standing crops compared to solid rows but, using seed costs from McBryde (1995), overall planting costs were 6% and 8% lower, respectively, because of reduced seeding rates/ha. Because skip 2 involves planting half of the food plot and allowing the other half to remain fallow, skip 2 planting schemes produced about 200% more forage than solid rows on a per hectare planted basis.

Differences in forage availability resulted from greater plant survival in the skip-row planting schemes, presumably the result of more efficient use of light and moisture in skip-rows (Mozingo 1984). Our conclusions are supported by the greater percentage of living plants in skip 2 schemes than in solid schemes on 24 August 1994 and the greater percentage of living plants in skip-row schemes than in solid schemes on 24 August 1995.

By incorporating a skip 2 planting scheme in a semi-arid environment that receives 15 to 21 cm of rainfall during the growing season: (1) overall planting cost was reduced 8% compared to solid planting while maintaining similar forage production; (2) percent plant survival throughout the summer was increased; and (3) availability of nutritious forage to deer during nutritionally-restricted periods was increased.

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