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Consumption of whole cottonseed by white-tailed deer and nontarget species

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Abstract: Supplementing diets of white-tailed deer (*Odocoileus virginianus*) with pelleted rations is an increasingly common practice aimed at increasing deer antler size on rangelands in Texas. Feed loss to consumption by various nontarget species (e.g., raccoons [*Procyon lotor*] and feral pigs [*Sus scrofa*]) raises both ecological and economic concerns. Whole cottonseed is a feedstuff that may afford a more targeted supplemental feeding effort. Accordingly, we determined: (1) consumption rates of whole cottonseed by feral pigs and raccoons in captivity; and (2) species visitation at feed sites and preference for whole cottonseed relative to whole corn under field conditions. For experiments 1 and 2, we trapped subadult feral pigs and raccoons (n = 16 for each) and randomly assigned them to 4 feed treatments. We weighed and took blood to assess gossypol levels from both pigs and raccoons every 2 weeks for 2 months. Pigs were adept at sorting cottonseed from their feed ration in the laboratory trial. Raccoons consumed cottonseed only under severe dietary stress (i.e., diets reduced to 60% of maintenance requirements). To supplement laboratory findings we used motion-triggered video camera systems to monitor species visitation and feeding behaviors in the field. Video surveillance (125 hours of recorded events) of feeders supported our observations from laboratory trials that cottonseed was unpalatable to feral pigs and raccoons, whereas white-tailed deer consumed cottonseed readily. Given our results, we believe that whole cottonseed merits further consideration as a supplement for free-ranging deer.

Key words: cottonseed, deer, feral pigs, gossypol, human–wildlife conflicts, raccoons, supplemental feeding, *Sus scrofa*, Texas

There is great interest in supplementing diets of white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*), especially in semiarid regions where variable precipitation impacts quantity and quality of forage (Machen 1996, Heffelfinger 2006). The goal of many deer managers is both increased antler size in males and fawn survival, especially during drought conditions (Bartoskewitz et al. 2003). Bartoskewitz et al. (2003) found that antler size increased up to 14% and that male body mass increased 12 to 23% with supplemental feeding programs in South Texas. Supplemental feeding programs also have been used to increase winter survival of cervids (Baker and Hobbs 1985, Smith 2001).

However, supplemental feeding of deer as a management practice is controversial, and there can be adverse ecological consequences (Brown and Cooper 2006). Rollins (2002) argued that supplemental feeding of deer as practiced currently over much of Texas (i.e., pelleted 16 to 17% protein rations) may be increasing ovulation rates or survival of raccoons (*Procyon lotor*) and feral pigs (*Sus scrofa*), thereby creating a potential liability for ground-nesting birds. Cooper and Ginnett (2000) found that survival of simulated nests of bobwhites (*Colinus virginianus*) and

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wild turkeys (*Meleagris gallopavo*) decreased linearly with proximity to deer feeders. Deer hunters and managers distributed an estimated 150,000 tons of whole corn feed in Texas in 1999 (R. N. Wilkins, Texas A&M University, unpublished data). How much pelleted rations are fed to deer annually is unknown, but it has likely increased greatly during the last 20 years, given the increasing popularity of intensive deer management in Texas. If Rollins's (2002) arguments of stimulating fecundity in feral hogs are true, deer managers may be inadvertently helping to increase a feral pest species, along with its attendant harm (Rollins et al. 2007).

Ecological concerns aside, feed loss to nontarget animals (e.g., raccoons, feral pigs) inflates the cost of feeding programs. Providing supplemental feed for deer is expensive; pelleted rations cost about $280/metric ton (2008 U.S. $). Bach (1998) estimated that approximately 20% of supplemental feed intended for deer was lost to pigs. Surveillance of deer feeders in west Texas with motion-sensing cameras revealed that deer comprised <30% of feeder visitations and that the most common nontarget species were raccoons (Figure 1; D. Rollins, Texas Agrilife Extension, unpublished data). In addition to raccoons and feral pigs, other common nontarget species encountered in Texas include opossums (*Didelphis virginiana*), collared peccaries (*Pecari tajacu*), porcupines (*Erethizon dorsatum*), fox squirrels (*Sciurus niger*), wild turkeys, and other birds.

Cottonseed has been used as a supplement for livestock for many years because of its favorable nutrient properties (Berardi and Goldblatt 1980), and it has the potential to reduce feed loss to nontarget species. Cottonseed contains gossypol (2,2′-binaphthalene)-8,8′-dicarboxaldehyde, 1,1′,6,6′,7,7′-hexahydroxy-3,3′-dimethyl-5,5′-bis (1-methylethyl), a naturally-occurring pigment in cottonseed that is toxic to monogastric animals. Ruminants show some resistance to gossypol toxicity (Abou-Donia 1976), thus, increasing its potential as a deer-specific feed supplement. However, limited data are available on the efficacy of using cottonseed as supplement feed for deer, with most information collected from studies conducted on fallow deer (*Dama dama*). Female fallow deer exhibited no negative effects in relation to pregnancy rates following consumption of relatively low concentrations of gossypol (8.1 $mg/kg^{-1}BW$; 0.41 $g/animal^{-1}/day^{-1}$) via ingestion of cottonseed meal (Maple 2004). Conversely, Brown (2001) reported negative effects after free-choice supplementation of whole cottonseed to male fallow deer. Gossypol intake in amounts up to 150 mg/kgBW (10.0/$g^{-1}/animal^{-1}/day^{-1}$) resulted in decreased body weight, body condition score, antler growth, and plasma testosterone concentration. In free-ranging white-tailed deer, Bullock et al. (2010) reported no detrimental effects from feeding whole cottonseed to deer.

Figure 1. Raccoons are among the most common nontarget species that visit deer feeders in Texas.

Because of uncertainty surrounding the efficacy of feeding cottonseed to white-tailed deer, we initiated laboratory and field studies to (1) quantify palatability and toxicity of cottonseed to raccoons and feral pigs under confined conditions, and (2) determine preference of cottonseed versus corn under field conditions by white-tailed deer, feral pigs, and raccoons.

Methods

Experiment 1: feral pigs

We captured 16 subadult feral pigs in Sutton County, Texas, and transported them to holding facilities at the Texas AgriLife Research Station near Sonora, Texas. Pigs were housed in individual 3.67 × 1.0 × 2.0-m covered pens. Four pigs (2 males, 2 females) were assigned to one of 4 treatment groups based on weight. Mean (+SE) pretreatment weights were 35.1 ± 2.7, 34.5 ± 1.5, 36.5 ± 5.3, and 34.7 ± 5.3 kg for the 0, 10, 20 and 30% groups, respectively. We provided diets that consisted of nutritionally-balanced rations containing 0, 10, 20, and 30% cottonseed, respectively. Soybean meal and milo were replaced with cottonseed to obtain the desired proportion of cottonseed; all rations were isonitrogenous and isocaloric for digestible energy.

We fed pigs their respective treatment rations ad libitum for 56 days and recorded feed intake daily. We collected and weighed orts daily. Collection trays (1.0-m^2) were made from plywood and placed under each feeder to facilitate ort collection. We cleaned the feeders at weekly intervals, and any remaining feed was collected. At the end of each trial, we sorted the cottonseed from the ration using a 1.2-cm^2 screen sifter. Remaining contaminants (e.g., mud, hair) that did not pass through the mesh were removed manually. We separated cottonseed and grain and recorded their weights; those values were subtracted from the known amount fed to compute cottonseed intake.

We bled pigs at 2-week intervals to obtain total blood plasma gossypol (TBPG) concentration. We monitored body weight changes at 14-day intervals using standard livestock scales. Upon completion of the trial, an attending veterinarian euthanized the animals and performed necropsies. We measured gossypol levels in the soft tissue (heart, liver, kidney, and muscle) collected at the time of death. The 2-amino propanol derivatives of (+)- and (–)-gossypol were separated by high-performance liquid chromatography. The procedure was conducted at the Texas AgriLife Research and Extension Center, San Angelo, Texas, under the supervision of M. C. Calhoun.,

Experiment 2: raccoons

We trapped 16 raccoons using cage traps at locations near San Angelo, Texas. We caged raccoons individually in 1.0 × 0.7 × 1.0-m welded wire cages housed inside an approved animal facility at the Texas AgriLife Research and Extension Center. We placed 4 raccoons in each of the 4 feed treatments based on body weight (i.e., 4 raccoons each on 0, 20, 40, and 60% feed restriction). Mean pre-treatment weights were 6.6 ± 0.9, 6.0 ± 0.5, 6.8 ± 0.8, and 5.8 ± 0.2 kg for the 0, 20, 40, and 60% restriction treatments, respectively.

We fed the control group a dog-food ration ad libitum for 1 week and fed raccoons in other treatment groups their respective amount of dog food. Groups 2, 3, and 4 were fed 20, 40, and 60% less dog food than the control, respectively. All treatment groups were provided cottonseed ad libitum in feed trays adjacent to where their dog-food rations were provided.

We fed raccoons their respective ration for 42 days with modified, gravity-flow rabbit feeders (Bronco Tuff Feeders, Sonora, Texas). Screen mesh (1-mm^2) was placed under the cage floors to capture any orts. We monitored the collection screens daily, and any cottonseed orts were separated to record intake of dog food and cottonseed. At 2-week intervals, an attending veterinarian sedated raccoons using 2.5 ml/kg body weight of Ketamine. Body weight of raccoons was determined using a spring-loaded scale, and blood samples were taken for analysis of TBPG concentrations. Upon completion of the trial, the veterinarian euthanized the raccoons and obtained tissue from the heart, liver, kidney, and muscle for subsequent gossypol analyses, as described above for pigs. Experiments 1 and 2 were conducted under an Animal Use Protocol approved by Texas A&M University (AUP # 2001-65).

Experiment 3: field surveillance

We used TrophyView™ video camera systems (Wildlife Surveillance Systems Inc., Kerens, Texas) to monitor species visitation and preference for cottonseed under field conditions. Cameras were used to assess feeder visitation over a 6-week period (February to March 2002) at 2 sites. Site 1 was on the Texas AgriLife Research and Extension Center near Sonora, Sutton County, Texas. Site 2 was located on a nearby private ranch located about 11 km east of site 1.

We set up camera systems to monitor feed trays (1.0-m^2) at pre-existing deer feeders. One camera was placed at each site facing the feed trays at a distance of ~7 m. For the first 2 weeks of the trial, corn was provided. On weeks 3 and 4, 2 feed trays (1 corn, 1 cottonseed) were placed in view of the camera systems. On week 5, we removed the corn tray, leaving only cottonseed for the final 2 weeks of the trial.

We reviewed videotapes and recorded species visitation, number of individuals, duration at feeder site (amount of time an individual animal spent at feeder), time spent actually feeding (as opposed to investigating), and feed preference (feed type chosen first when both corn and cottonseed were present). A feeding event was recorded if the animal put its mouth in the feed tray. Successive events were not counted as a new event if we were able to discern that the same animal(s) returned to the feeder within 30 minutes. This was an attempt to ensure independence among successive observations. Events were excluded from feed preference analysis if either of the feeds had been consumed completely at the onset of a video event.

Table 1. Total blood plasma gossypol concentration (μg/ml) for feral pigs exposed to cottonseed at various levels in their diet for 56 days, Edwards County, Texas, 2002.

Treatment	Day 0	Day 14	Day 28	Day 42	Day 56
Control	0.8[a]	0.4[a]	0.6[a]	0.7[a]	0.7[a]
10% cottonseed	0.5 [a]	25.7[b]	23.7[b]	29.1[b]	38.4[b]
20% cottonseed	0.5 [a]	35.1 [b]	33.2[b]	42.4[b,c]	46.7[b]
30% cottonseed	0.4 [a]	41.0 [b]	27.4[b]	46.6[c]	35.5[b]

[a, b, c]Means within columns followed by different letters are significantly different.

Table 2. Organ gossypol concentration (LSM) (μg/ml) of feral pigs exposed to cottonseed for 56 days at various levels in their diet, Edwards County, Texas, 2002.

Treatment	Heart	Liver	Kidney	Muscle
Control	5.0[a]	19.7[a]	5.0[a]	0.0[a]
10% cottonseed	91.3[b]	538.9[b]	78.1[b]	24.2[b]
20% cottonseed	123.1[b]	582.1[b]	131.5[b]	30.0[b]
30% cottonseed	98.7[b]	504.0[b]	90.6[b]	20.9[b]

[a,b]Means within columns followed by different letters are significantly different.

Statistical analyses

We used repeated measure analysis of variance (SAS 1994) in experiments 1 and 2 to test for treatment effects (cottonseed intake) using intake, weight gain, TBPG, and tissue gossypol levels as dependent variables. Individual animals were nested within treatments and served as replicates. We collected data every 14 days throughout experiments 1 and 2; collection date served as a repeated measure. We separated means using Duncan's multiple range test when $P < 0.05$. We analyzed data using the statistical computer package JMP (SAS 1994), and we report descriptive statistics ($\bar{x}$ ± SE) for experiment 3 only.

Results

Experiment 1: feral pigs

We observed cottonseed consumption by pigs in all treatment groups. Cottonseed consumption differed across treatments ($P < 0.01$) and dates ($P = 0.1$). Consumption of cottonseed ranged from 15.2 ± 2.0 g/day in ration group 1 (10% cottonseed) to 45.5 ± 7.0 g/day in ration group 3 (30% cottonseed). Feral pigs tended to sort cottonseed out of rations across all treatment groups and became proficient at minimizing cottonseed intake. Preference for grain versus cottonseed was evidenced by comparing the consumption of available cottonseed (ranging from 43 to 59%) to that of consumption of grain (ranging from 86 to 93%).

Total blood plasma gossypol levels increased rapidly by day 14 in all treatment groups receiving cottonseed and then leveled off for the duration of the trial (Table 1). All treatment groups had greater TBPG levels than the control group across all sampling dates ($P < 0.05$). Low levels of TBPG in the control group suggested that either trace consumption of cottonseed by those pigs had occurred (i.e., cottonseed may have become available from adjacent feeding stalls) or low background levels in the detection technique. All treatments had higher levels of TBPG on Day 14 than on Day 28, but following this initial decline, TBPG in animals in the 10 and 20% cottonseed rations increased until the end of the trial. Total blood plasma gossypol peaked on Day 42 and declined thereafter for the 30% cottonseed treatment. There were no differences in organ gossypol concentration among pigs receiving cottonseed in their diets (Table 2), although animals in the 20% cottonseed ration had higher organ gossypol concentrations than did all other groups.

No pigs died during the trial. Indeed, all pigs gained weight over the duration of the study. Gains averaged 18.1 ± 1.6, 13.1 ± 2.5, 9.3 ± 0.9, and 5.4 ± 0.9 kg for the 0, 10, 20, and 30% treatments, respectively.

Experiment 2: raccoons

We were unable to record accurately cottonseed intake by raccoons. Cottonseed disappearance was monitored from feeders daily, but raccoons scattered it in such a way that orts could not be measured accurately. Total blood gossypol levels tended to increase over the duration of the trial (Table 3), with significance noted initially at the 60% restriction group (after 14 days) and later (at 42 days) at the 40% restriction level. Tissue gossypol trends confirmed trends found in TBPG that 40% and 60% restriction groups had greater levels of gossypol than control and 20% restriction groups ($P < 0.05$; Table 4).

Table 3. Total blood plasma gossypol concentration (µg/ml) for raccoons exposed to cottonseed at various levels of dietary restriction for 42 days, Tom Green County, Texas, 2002. (20, 40, and 60% feed restriction groups also were provided cottonseed ad libitum.)

Treatment[1]	Day 0	Day 14	Day 28	Day 42
Control	0.0[a]	0.7[a]	0.6[a]	0.2[a]
20% feed restriction	0.0[a]	0.3[a]	0.1[a]	0.1[a]
40% feed restriction	0.0[a]	0.2[a]	7.7[b]	7.7[b]
60% feed restriction	0.0[a]	6.4[b]	8.3[b]	8.3[b]

[a, b] Means within columns followed by different letters are significantly different.

Table 4. Tissue gossypol concentration (µg/ml) for raccoons exposed to cottonseed at various levels of dietary restriction at the conclusion of a 42-day feeding trial, Tom Green County, Texas, 2002.

Treatment	Heart	Liver	Kidney	Muscle
Control	1.7[a]	6.2[a]	3.1[a]	0.4[a]
20% feed restriction	0.0[a]	1.9[a]	0.6[a]	0.1[a]
40% feed restriction	22.2[a, b]	72.5[b]	38.2[a]	2.0[a]
60% feed restriction	39.9[b]	91.0[b]	67.4[b]	4.5[a]

[a, b]Means within columns followed by different letters are significantly different.

All treatment groups lost weight over the duration of the trial, but no animals died. Weight loss ranged from a maximum of 26.9 + 3.6 g/day for the 60% restriction group, to a minimum of 19.2 + 10.0 g/day for the control group. The amount of ration fed to the control group in the raccoon trial was intended to comprise a maintenance level, but apparently maintenance requirements either were not met or stress due to confinement depressed intake.

Experiment 3: field observations

Video surveillance across both sites yielded 592 feeding events. White-tailed deer were the species observed most frequently (n = 223; 38% of total visitations). Other species included feral pigs (n = 146; 25%), wild turkeys (n = 87; 15%), and raccoons (n = 77; 13%). Site 1 recorded 378 visitations. Deer represented the highest number of recorded visits (n = 223; 59%) followed by raccoon (n = 68; 18%), wild turkeys (n = 38; 10%), and collared peccaries (n = 38; 10%). Site 2 recorded 214 visits, but did not record any feeding events for deer. We assumed the lack of recorded visits by deer was a result of the higher incidence of feral pigs at this site (n = 146; 68% of total visitations).

Deer spent an average of 5.6 + 0.6 minutes feeding on corn across sites 1 and 2. They spent an average of 8.2 + 1.7 minutes feeding on cottonseed while corn was present versus 7.8 + 0.5 minutes feeding on cottonseed when corn was removed across all sites. Feral pigs spent an average of 3.3 + 0.7 min across both sites exhibiting feeding behavior in the cottonseed tray (albeit the majority of that time was spent rooting through the cottonseed) while corn was present, 2.2 + 1.1 minutes when corn was removed, and an average of 25.0 + 2.8 minutes feeding on corn. Raccoons spent an average of 27.0 + 4.9 minutes feeding on corn, and turkeys spent an average of 39.5 + 15.2 minutes feeding on corn across both sites. There were no recorded instances of raccoons or turkeys consuming cottonseed.

Discussion

Our findings suggest that cottonseed has potential for use as a targeted feed for deer. Laboratory feeding trials and field surveillance indicated that neither feral pigs nor raccoons found cottonseed to be palatable. Feral pigs exhibited an avoidance behavior in the feeding trial by sorting the cottonseed out of their diets and consumed minimal amounts of cottonseed in the field. The ability of feral pigs to sort out most of the cottonseed allowed them to effectively self-regulate their consumption of cottonseed. However, Campbell et al. (2010) demonstrated that feral pigs would travel distances (<3.2 km) to consume whole cottonseed.

Dietary restriction led to increased consumption of cottonseed by raccoons in feeding trials, as evidenced by higher levels of blood and tissue gossypol as feed restriction increased. The dietary stress imposed in this study that was required to observe cottonseed consumption by raccoons (i.e., >40% feed restriction over considerable time) is unlikely in the wild, given a raccoon's omnivorous diet. Raccoons in Texas are opportunistic omnivores (Davis and Schmidly 1994) and likely would not be subjected to the levels of intake restriction we imposed.

Video surveillance indicated that feral pigs and raccoons avoided cottonseed when corn was present, whereas white-tailed deer showed no preference for corn or cottonseed. Feral pigs spent a minimal amount of time consuming cottonseed; most of that time was spent rooting in the feeding tray, presumably in search of corn. Deer spent equal amounts of time feeding on cottonseed whether in the presence or absence of corn. Feeding behavior of nontarget species shifted from longer feeding times to short searches for corn when only cottonseed was provided. In an ecological context, this reduction in visits and time could be beneficial to ground-nesting birds (e.g., wild turkeys and bobwhites; Cooper and Ginnett 2000).

Other considerations must be addressed before feeding cottonseed to white-tailed deer. Gossypol toxicity varies among species, and excessive levels of it can be toxic to ruminants (Maple 2004). Brown (2001) reported decreased antler growth and suppression of basal testosterone in fallow deer (*Dama dama*) when fed cottonseed meal ad libitum. Although the response of fallow deer ingesting cottonseed does not necessarily mean that white-tailed deer would respond the same (e.g., gossypol causes reversible male infertility when given orally to laboratory rats, but not when given to mice [Nomeir and Abou-Donia 1985]). Bullock et al. (2010) demonstrated that plasma gossypol levels in white-tailed deer decreased rapidly after cottonseed was removed from the diet. They also reported that gossypol levels in deer 5 weeks after it has been removed from the diet were not detrimental to sperm formation or animal health.

In conjunction with possible liabilities of feeding cottonseed, there may be multiple ecological concerns associated with any form of intensive supplemental feeding of deer (e.g., disease transmission, habitat degradation, and ethical concerns; Brown and Cooper 2006). The long-term implications of supplementing wild cervids are controversial because of potential detrimental impacts to the diversity of browse plants (Murden and Risenhoover 1993, Brown and Cooper 2006). Cooper et al. (2006) estimated that browsing pressure near the feeder was 7 times heavier than at the control sites. Given the possible benefits of reducing visitations by nontarget species, and the controversial nature of supplemental feeding, future experiments need to be initiated to estimate the effects of cottonseed as the supplement as opposed to corn.

Management implications

Feeding cottonseed as a deer-specific supplement appears promising. Nontarget species avoided cottonseed, whereas white-tailed deer consumed cottonseed readily. The protective seed coat and high oil content in cottonseed makes it weather resistant, which allows it to be fed in open livestock feed troughs or piled on the ground at a feed site. Similarity in prices between whole cottonseed (approximately $310 to $315/metric ton [2012 U.S. prices]) and pelleted rations (approximately $280/metric ton) make feeding cottonseed economically encouraging, especially if deer are the sole beneficiaries of the cottonseed.

Given the popularity of supplementation for deer in Texas (and increasingly elsewhere) and the rapidly-increasing abundance of feral hogs across much of the United States, we argue that a more deer-specific feed might help slow reproduction in feral pigs. Such alternatives deserve future research attention.

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Literature cited

Abou-Donia, M. B. 1976. Physiological effects and metabolism of gossypol. Residue Review 61:125–160.

Bach, J. P. 1998. Economic impacts of wild hogs on selected Texas agriculture operations. Thesis, Texas A&M University, College Station, Texas, USA.

Baker, D. L., and N. T. Hobbs. 1985. Emergency feeding of mule deer during winter: tests of a supplemental ration. Journal of Wildlife Management 49:934–942.

Bartoskewitz, M. L., D. G. Hewitt, J. S. Pitts, and F. C. Bryant. 2003. Supplemental feed use by free-ranging white-tailed deer in southern Texas. Wildlife Society Bulletin 31:1218–1228.

Berardi, L. C., and L. A. Goldblatt. 1980. Gossypol. Pages 183–237 *in* I. E. Liener , editor. Toxic constituents of plant foodstuffs. Academic Press, New York, New York, USA.

Brown, C. G. 2001. Evaluation of whole cottonseed consumption on growth and reproductive function in male cervids. Thesis, Texas A&M University, College Station, Texas, USA.

Brown, R. D., and S. Cooper. 2006. The nutritional, ecological, and ethical arguments against baiting and feeding white-tailed deer. Wildlife Society Bulletin 34:519–524.

Bullock, S. L., D. G. Hewitt, R. L. Stanko, M. K. Dowd, J. Rutledge, and D. A. Draeger. 2010. Plasma gossypol dynamics in white-tailed deer: implications for whole cottonseed as a supplemental feed. Small Ruminant Research 93:165–170.

Campbell, T. A, S. L. Bullock, D. B. Long, D. G. Hewitt, and M. K. Dowd. 2010. Visitation to cottonseed storage sites by feral swine and evidence of gossypol exposure. Human–Wildlife Interactions 4:145–151.

Cooper, S. M, and T. F. Ginnett. 2000. Potential effects of supplemental feeding of deer on nest predation. Wildlife Society Bulletin 28:660–666.

Cooper, S. M., M. K Owens, R. M. Cooper, and T. F. Ginnett. 2006. Effect of supplemental feeding on use of space and browse utilization by white-tailed deer. Journal of Arid Environments 66:716–726.

Davis, W. B., and D. J. Schmidly. 1994. The mammals of Texas. Texas Parks and Wildlife Department, Austin, Texas, USA.

Forster, L. A., and M. C. Calhoun. 1995. Nutrient values for cottonseed products deserve new look. Feedstuffs 67:1–5.

Heffelfinger, J. R. 2006. Deer of the Southwest. Texas A&M University Press, College Station, Texas, USA.

Machen, R. V. 1996. Non-traditional feedstuffs as supplements for deer. Pages 23–28 *in* C. W. Ramsey, editor. Supplemental feeding for deer: beyond dogma. Texas AgriLife Extension Service, Kerrville, Texas, USA.

Maple, S. L. 2004. Effect of cottonseed meal consumption on performance of female fallow deer. Thesis, Texas A&M University, College Station, Texas, USA.

Murden, S. B., and K. L. Risenhoover. 1993. Effects of habitat enrichment on patterns of diet selection. Ecological Applications 3:497–505.

Nomeir, A. A., and M. B. Abou-Donia. 1985. Toxicological effects of gossypol. Pages 111–130 *in* T. Lobol and E. S. F. Hafez, editors. Male fertility and its regulation. MTP Press, Langcaster, England.

Rollins, D. 2002. Sustaining the ‘quail wave’ in the southern Great Plains. Pages 48–56 *in* S. J. DeMaso, W. P. Kuvlesky Jr., F. Hernandez, and M. E. Berger, editors. Quail V: proceedings of the national quail symposium. Texas Parks and Wildlife Department, Austin, Texas, USA.

Rollins, D., B. J. Higginbotham, K. A. Cearley, and R. N. Wilkins. 2007. Appreciating feral hogs: extension education for diverse stakeholders in Texas. Human–Wildlife Conflicts 1:192–198.

SAS Institute. 1994. JMP statistics and graphics guide. Version 3.1. SAS Institute Inc., Cary, North Carolina, USA.

Smith, B. L. 2001. Winter feeding of elk in western North America. Journal of Wildlife Management 65:173–190.

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