

Large herbivores suppress liana infestation in an African savanna

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African savannas are the last stronghold of diverse large-mammal communities, and a major focus of savanna ecology is to understand how these animals affect the relative abundance of trees and grasses. However, savannas support diverse plant life-forms, and human-induced changes in large-herbivore assemblages—declining wildlife populations and their displacement by livestock—may cause unexpected shifts in plant community composition. We investigated how herbivory affects the prevalence of lianas (woody vines) and their impact on trees in an East African savanna. Although scarce (<2% of tree canopy area) and defended by toxic latex, the dominant liana, *Cynanchum viminale* (Apocynaceae), was eaten by 15 wild large-herbivore species and was consumed in bulk by native browsers during experimental cafeteria trials. In contrast, domesticated ungulates rarely ate lianas. When we experimentally excluded all large herbivores for periods of 8 to 17 y (simulating extirpation), liana abundance increased dramatically, with up to 75% of trees infested. Piecewise exclusion of different-sized herbivores revealed functional complementarity among size classes in suppressing lianas. Liana infestation reduced tree growth and reproduction, but herbivores quickly cleared lianas from trees after the removal of 18-y-old exclosure fences (simulating rewilding). A simple model of liana contagion showed that, without herbivores, the long-term equilibrium could be either endemic (liana–tree coexistence) or an all-liana alternative stable state. We conclude that ongoing declines of wild large-herbivore populations will disrupt the structure and functioning of many African savannas in ways that have received little attention and that may not be mitigated by replacing wildlife with livestock.

competition and facilitation | DNA metabarcoding | defaunation | ecological regime shifts | trophic rewilding

Tropical savannas, which are defined by coexistence of grasses and trees, cover ~13% of global land surface and support large populations of mammalian wildlife and livestock (1). The distribution of savannas is strongly influenced by fire and rainfall (2–4), which interact to maintain savannas in an intermediate state between forest and grassland. In Africa, large herbivores also influence savanna vegetation at local-to-continental scales, and shifts in herbivory regime influence the balance of trees and grasses (5, 6) with ramifications for biodiversity and ecosystem functions (4, 7). Accordingly, competitive interactions between trees and grasses, and the effects of abiotic and biotic disturbances on the relative abundance of these plant types, are major themes in savanna ecology (8, 9). By contrast, little research has addressed the potential effects of direct and indirect interactions involving other plant life-forms, such as forbs, succulents, and vines (10).

In tropical forests, lianas (woody vines) play a key role in regulating tree abundance, diversity, growth, and survival. In the Neotropics, liana abundance has increased over the last 40 y in response to intensifying anthropogenic disturbance, rising atmospheric

CO₂, and hydrological changes (11, 12). Such perturbations are thought to benefit lianas relative to trees, in part because lianas have greater capacity for growth during drought (13, 14), invest less in structural tissues (15), and can colonize rapidly via clonal reproduction (16, 17). In light-rich treefall gaps, lianas often proliferate and can competitively suppress forest regeneration for decades (18, 19).

The limited available evidence suggests that lianas are widespread but locally rare in savannas (20, 21). On the one hand, this scarcity may reflect fundamental differences between biomes: the discontinuous tree cover that defines savannas, for example, may restrict the establishment and spread of a plant life-form that uses woody canopies for structural support (18, 22). On the other hand, lianas may be a potentially significant presence in savannas that have simply been overlooked owing to strong top-down control by herbivores combined with a bias toward studying systems with intact wildlife assemblages (23). If savanna lianas are regulated by mammalian browsers, then the decline of large herbivores in Africa—especially threatened megaherbivores such as elephant and giraffe (24)—may lead to

Significance

Declines of wild megafauna are expected to transform ecosystems and are known to influence tree–grass balance in African savannas, but the effects of large herbivores on lianas are unknown. Using diet analysis, long-term exclosure experiments, and smaller-scale manipulations, we show that liana infestation occurred rapidly after the loss of large herbivores and suppressed tree growth and reproduction. We show theoretically that extended absence of herbivores could potentially generate a liana-dominated alternative state—but both experimental and theoretical results indicate that herbivore reintroduction can reverse endemic infestation, even after decades. We found low functional redundancy among wild herbivore species and between wildlife and livestock. Our results suggest that diverse large-herbivore assemblages promote resilience and robustness of savannas to liana encroachment.

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rapid increases in liana abundance analogous to those in Neotropical forests. The determinants of liana cover in savannas and the impacts of lianas on savanna trees are essentially unstudied, and lianas are often omitted from savanna plant censuses (25).

We combined small- and large-scale field experiments with diet analyses to understand the effects of large herbivores on lianas and liana–tree interactions in a semiarid Kenyan savanna. We hypothesized that browsers control liana abundance, thereby mitigating the negative effects of lianas on trees. Specifically, we predicted that native herbivores frequently eat lianas but that livestock rarely do; that experimental exclusion of large herbivores would increase the abundance and size of lianas; and that liana infestation would reduce tree growth and reproduction. We also experimentally assessed the resilience of this system to nearly two decades of large-herbivore exclusion, predicting that liana cover would decrease rapidly when large herbivores were

“reintroduced” (by removing exclosure fences) after 18 y. Last, for insight into the potential dynamics of lianas and trees on even longer timescales, we developed a simple differential equations model analogous to the SIR (susceptible-infected-recovered) class of models commonly used in epidemiology.

Results

We collected data at the Mpala Research Centre and Conservancy in the Laikipia highlands of central Kenya (0°20′ N, 36°53′ E, mean annual rainfall ~630 mm). The tree community is dominated by several species of *Acacia sensu lato* (25, 26). Caustic creeper (*Cynanchum viminalis* [syn. *Sarcostemma viminalis*], Apocynaceae, henceforth “*Cynanchum*,” ref. 27), a wind-dispersed, succulent vine with a woody trunk, is the dominant climber and accounts for >85% of vine infestations in tree canopies. The branching stems of *Cynanchum* produce white latex

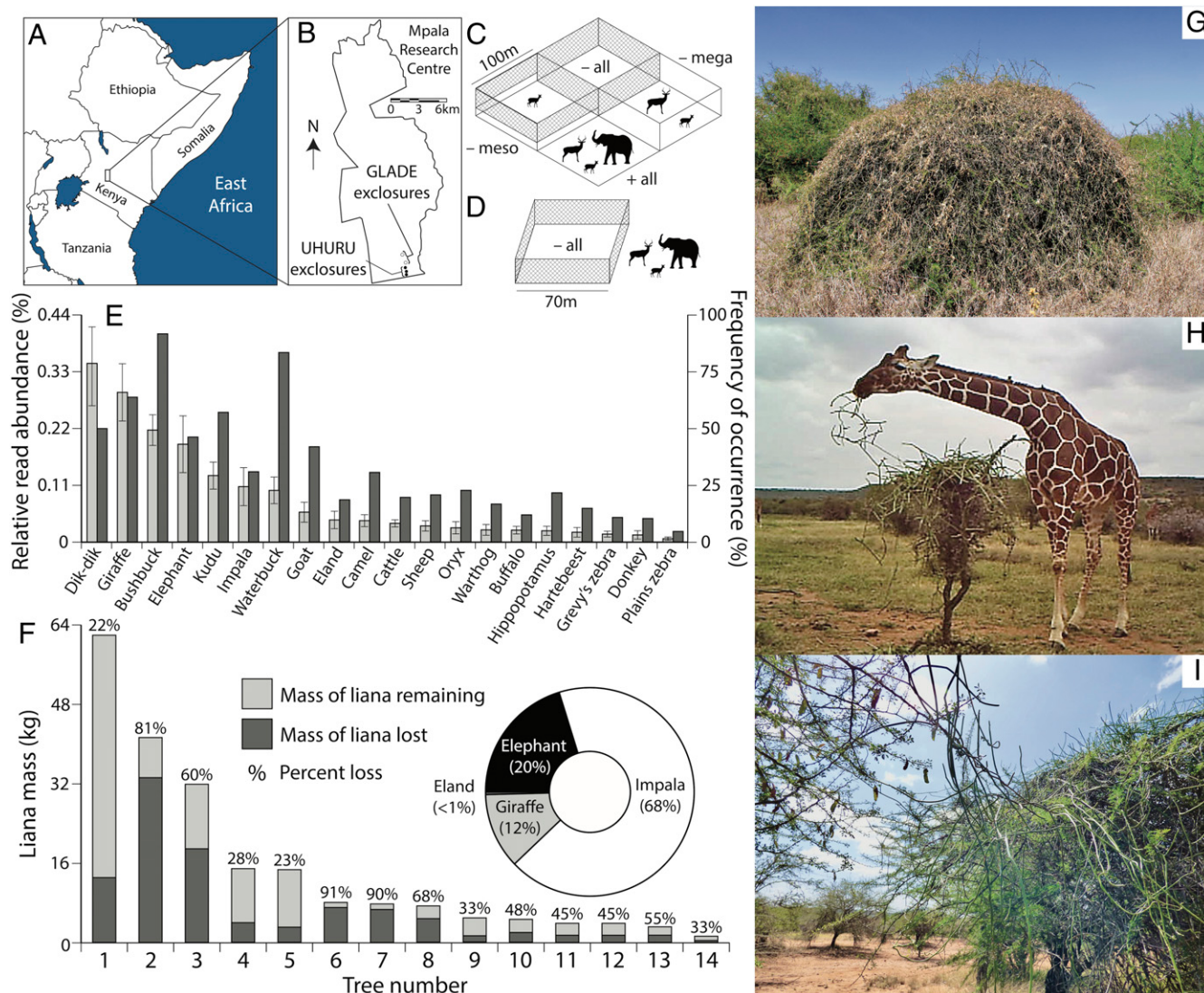


Fig. 1. Liana–herbivore–tree interactions at Mpala Research Centre, Kenya. (A) Location of Mpala and (B) southern GLADE and UHURU herbivore exclosures. Schematics of (C) UHURU and (D) GLADE experiments. (E) Relative read abundance (mean percent *Cynanchum* DNA per fecal sample $\pm$ SEM; light-gray bars, Left y-axis) and frequency of occurrence (percentage of samples with $\geq 0.1\%$ *Cynanchum* DNA; dark-gray bars, Right y-axis) of *Cynanchum* in the diets of 20 large-herbivore species at Mpala (SI Appendix, Tables S1 and S2). (F) Consumption of transplanted lianas in 14 trials lasting 4 to 20 d (mean 9.8 d, mean percent weight loss per day across replicates $7.9 \pm 1.9\%$ SEM). Bar height is total mass transplanted, light gray is mass reweighed after the trial, and dark gray is the difference (mass lost); numbers above bars show percent of initial wet mass lost for each liana. Inset shows frequency of herbivory by different browsers in $n = 247$ recorded herbivory events. (G) Heavily infested *A. etbaica* in a total-exclusion (–all) plot in UHURU. (H) Giraffe eating transplanted liana (Movies S1–S4 show illustrative camera-trap footage). (I) Lateral spread of *Cynanchum* between adjacent tree canopies.

containing pregnane glycosides that can cause convulsions and paralysis in livestock (28). The large-herbivore (≥ 5 kg) community includes 22 wild species, along with cattle, camel, sheep, goat, and donkey. We worked in two long-term large-herbivore-exclusion experiments (Fig. 1 A–D): UHURU (Ungulate Herbivory Under Rainfall Uncertainty, established 2008) comprises four size-selective treatments applied to 1-ha plots in randomized blocks; GLADE (Glade Legacies and Defaunation Experiment, established 1999) comprises 0.5-ha total-exclusion plots (29). Here, we focused on the southernmost replicates of UHURU ($n = 3$ blocks, 12 plots) and GLADE ($n = 2$ plots), all of which are ≤ 2.5 km apart. The two GLADE exclusions were removed in 2017, enabling us to measure effects of herbivore reintroduction after nearly two decades of exclusion. The three unfenced control plots in UHURU, where herbivores have unfettered access, served as our reference point for the effects of exclusion.

Consumption of Lianas by Large Herbivores. We extracted publicly available diet data produced by DNA metabarcoding fecal samples collected at Mpala over multiple seasons and years (30–32). We analyzed data for the 20 most common herbivore species to assess the frequency and relative intensity of consumption of *Cynanchum*. For seven native species, *Cynanchum* accounted for 0.10 to 0.35% of diet (i.e., mean proportion of dietary sequence reads per sample) and occurred in 31 to 92% (median 57%) of samples (Fig. 1E). Some individuals of the four dominant browsers (dik-dik, impala, giraffe, and elephant) ate larger proportions of *Cynanchum* (up to 5.2, 4.5, 2.5, and 3.7%, respectively). By contrast, among the five livestock species, *Cynanchum* accounted for only 0.01 to 0.06% of diet, occurred in just 10 to 42% (median 21%) of samples, and never accounted for $>0.5\%$ of sequence reads in any individual sample (Fig. 1E and SI Appendix, Tables S1 and S2).

Although *Cynanchum* was frequently eaten by multiple species, it was not abundant in any species' average diet, which could reflect either low availability or low herbivore preference. We therefore performed a cafeteria-style experiment in which we transplanted large *Cynanchum* (mean $\pm$ SEM, 14.9 ± 4.8 kg) from trees in exclusions onto trees accessible to herbivores. Transplanted lianas were rapidly consumed, losing $51.5 \pm 6.4\%$ of initial wet weight in trials lasting an average of 10 d (Fig. 1F). Most of this loss was attributable to consumption rather than desiccation: lianas transplanted onto trees in a fenced exclusion lost only $16.5 \pm 2.1\%$ of initial wet weight over 10 d, suggesting that $\sim 35\%$ of transplanted liana biomass was eaten by herbivores. Camera-trap footage showed that impala, elephant, and giraffe were the main consumers of transplanted lianas (Fig. 1F and H and Movies S1–S4). Thus, native browsers ate substantial quantities of *Cynanchum* when it was available, suggesting that its low relative abundance in herbivore diets is a function of its limited abundance in the landscape.

Effects of Herbivore Exclusion on Liana Infestation. All measures of liana abundance and infestation severity were lowest in unfenced (“+all”) plots and increased monotonically with the successive exclusion of elephant and giraffe (“–mega”), mesoherbivores (predominantly impala, “–meso”), and dik-dik (“–all”), although not all treatments differed significantly in pairwise contrasts (Fig. 2 and SI Appendix, Fig. S1). Mean proportion of trees infested (Fig. 2A) and percent cover of lianas on tree canopies (Fig. 2C) were suppressed most strongly by mega- and mesoherbivores, with limited additional effect of dik-dik, whereas herbivores of all sizes contributed similarly to reducing the mean number of individual lianas per tree (Fig. 2D). The subset of responses measured in the 17-y GLADE –all exclusions were two- to threefold stronger than those in the 8-y UHURU –all plots (Fig. 2C and D). These results were reproduced in a separate survey in November 2018 (10 y into UHURU), when we measured plant species composition by passing a 6-m pin from

the ground through the canopy and recording all vegetation touching the pin. *Cynanchum* abundance increased monotonically from +all to –all treatments, accounting for nearly 10% of the vegetation in some exclusion plots (SI Appendix, Fig. S1A). Moreover, mean height of *Cynanchum* pin hits decreased from –mega, to –meso, to –all plots (SI Appendix, Fig. S1B), as expected if browsers in each size class ate the lianas within reach. These data show that herbivores exert strong top-down control on lianas, that effects of different-sized herbivores are additive and complementary (not redundant), and that infestation severity increases over time in the absence of herbivores.

In contrast to lianas, mean density and estimated biomass of trees (>1 -m tall) in UHURU were greatest in –meso exclusions and least in +all and –all plots (although the density response was not statistically significant; Fig. 2B). The discrepant responses of trees and lianas reinforce our conclusion that herbivores' effects on lianas were direct and consumptive, as opposed to purely indirect effects mediated by tree density.

Liana recruitment was greatest in exclusions and beneath tree canopies (Fig. 2E and F), suggesting strong influences of both herbivores and the number and proximity of large adult lianas. Juvenile lianas in open habitat (i.e., not beneath trees) were almost nonexistent in +all plots and most abundant in –all plots, showing that dik-dik play a major role in suppressing recruitment outside tree canopies (Fig. 2E). Across all treatments, however, juvenile liana density was more than an order-of-magnitude greater beneath tree canopies than in the open, indicating that trees provide associational refuges from even the smallest ungulates (26). The annual growth rate of individually tagged liana stems did not differ significantly across exclusion treatments, but the fastest growing $\sim 2\%$ of stems grew 43 to 593 cm/y, showing that liana growth and tree-to-tree spread can be rapid.

Using data from semiannual (wet and dry season) surveys in UHURU, we found that *Cynanchum* also constituted an appreciable fraction of the understory after 10 y—but only in –all plots, where they accounted for an average of 3% (max 18%) and 2.5% (max 12%) of understory pin hits per plot in October 2018 (wet) and February 2019 (dry), respectively (SI Appendix, Fig. S1C). In contrast, *Cynanchum* was essentially undetected in the understory of the other three treatments (e.g., one solitary pin hit in a single –meso plot in 2019), further underscoring the role of dik-dik in suppressing recruitment. Mean prevalence of *Cynanchum* in the understory of –all plots increased exponentially across 20 surveys from 2008 to 2019 ($R^2 = 0.87$; SI Appendix, Fig. S1D).

Observations in March 2021 (12.5 y into UHURU) indicated that *Cynanchum* prevalence has continued to increase in –all plots, where it dominated large swaths of understory and overstory vegetation (SI Appendix, Fig. S2). Importantly, many free-standing lianas (understory individuals unsupported by trees) had reproduced, suggesting that *Cynanchum* does not need trees to persist (SI Appendix, Fig. S2A and E).

Effects of Herbivore Reintroduction on Liana Cover. Removal of the GLADE exclusions in 2017 provided an unusual opportunity to test the resilience of this system after 18 y without large herbivores. Shortly before fence removal, liana prevalence in these exclusions was the highest we measured anywhere (Fig. 2C and D), with lianas covering $>50\%$ of the average tree canopy. Within 2 mo of fence removal, mean liana cover decreased by more than half, to $23.9 \pm 3.0\%$ (Fig. 3), corroborating our transplant experiment showing that lianas are consumed in large quantities when available. Over roughly the same period, liana cover was stable in UHURU –all plots ($-2.8 \pm 3.7\%$; Fig. 3), indicating that the change in the deconstructed exclusions was the result of herbivory.

Effects of Lianas on Trees. Trees infested with lianas grew 5.2 ± 3.2 cm per year. Trees from which we experimentally removed lianas grew nearly three times more over the same period ($14.9 \pm$

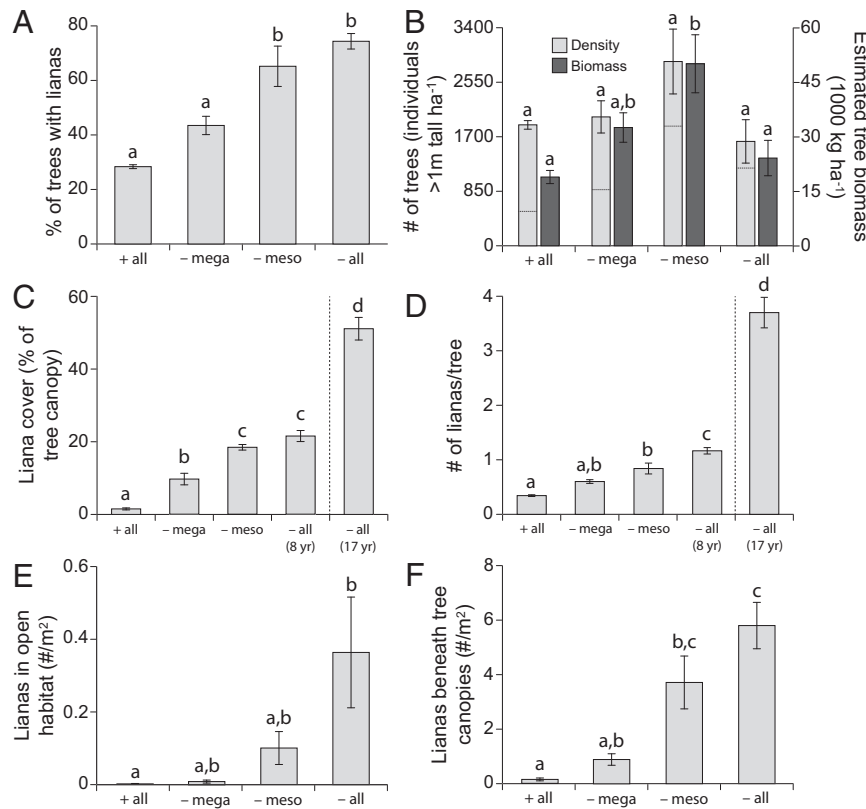


Fig. 2. Responses of lianas and trees to experimental herbivory regimes. (A) Percentage of trees infested by *C. viminale* in each treatment ($F_{3,8} = 23.22$, $P = 0.0003$). (B) Light bars, Left y-axis: density of all trees >1-m tall ($F_{3,8} = 2.67$, $P = 0.12$); dotted lines show estimated mean number of liana-infested trees, inferred by multiplying the proportion of trees infested by tree density. Dark bars, Right y-axis: estimated biomass density of trees >1-m tall ($F_{3,8} = 6.95$, $P = 0.013$). (C) Percent cover of lianas on individual tree canopies ($F_{4,9} = 333.96$, $P < 0.0001$). (D) Number of individual lianas per tree ($F_{4,9} = 139.70$, $P < 0.0001$). Number of juvenile lianas rooted in (E) open habitat between tree canopies ($F_{3,8} = 4.54$, $P = 0.039$) and (F) beneath tree canopies ($F_{3,8} = 15.92$, $P = 0.001$). All data are from the UHURU experiment except for the 17-y –all treatment shown at right of the vertical dotted lines in C and D, which are from GLADE enclosures prior to fence removal. Data are plot-level means ± 1 SEM ($n = 3$ plots per treatment in UHURU, 2 plots in GLADE). Statistical tests are from one-way ANOVA by treatment; letters denote significant differences between treatments in post hoc contrasts (Tukey's HSD).

3.5 cm). Uninfested, unmanipulated control trees grew intermediately (8.0 ± 1.4 cm; Fig. 4A). Tree reproductive output also declined as a function of infestation severity, with heavily infested *Acacia etbaica* producing up to 85% fewer fruits and flowers than lightly infested conspecifics (Fig. 4B). In 2021, we found that multiple heavily infested trees in –all plots had been top killed (SI Appendix, Fig. S2G), and we have seen trees broken under heavy masses of lianas (which can exceed 100 kg; reference Fig. 1F). Thus, lianas competitively reduce tree fitness, but individual trees can tolerate infestation up to a point and recover if lianas are removed.

Theoretical Model. We built a simple, spatially implicit ordinary differential equations model to qualitatively explore the long-term dynamics of trees and lianas (SI Appendix, Supplementary Information Text and Fig. S3). This model is analogous to epidemiological models used to study disease transmission, which have recently been adapted to study the dynamics of Neotropical lianas (33). Trees and lianas compete for space and resources. Trees can be either healthy (S) or infested (I), and lianas can be either free-standing (L) or growing on trees (henceforth, climbers). We modeled infestation as a contagion process in which both free-standing and climbing lianas can spread to and infest healthy trees. Free-standing lianas and climbers both produce seeds that are wind dispersed and therefore assumed to be randomly scattered across the landscape (SI Appendix, Fig. S2). Germinating seeds give rise to free-standing lianas; we assume that these (like *Cynanchum*: ref. 34) can grow adventitious roots and thus vegetatively grow

laterally until they encounter a tree that they can climb (regardless of distance). Thus, we assume that infestation by free-standing lianas is a density-dependent process. Climbers can cause new infestations via lateral spread to neighboring, possibly healthy trees. Thus, we assume that infestation by climbing lianas is a frequency-dependent process. We further assume that both seed production and vegetative growth are higher for climbers than for free-standing lianas; conversely, consistent with our empirical observations, infested trees have lower reproduction and higher mortality than healthy trees. Herbivores increase mortality of both trees and lianas. We incorporated the herbivory regime by including separate herbivore-induced mortality terms for healthy trees, infested trees, and lianas in addition to their natural death rates (SI Appendix, Supplementary Information Text); thus, the effects of herbivores (collectively) are either present (i.e., herbivore-induced mortality terms are positive, albeit not necessarily equivalent) or absent (i.e., herbivore-induced mortality terms are zero). Although the model is agnostic as to the “type” of herbivore exerting these effects (e.g., wild versus domestic), different intensities and regimes of herbivory can be simulated by varying the absolute and/or relative magnitudes of the herbivore-induced mortality terms for the different categories of plant (e.g., SI Appendix, Fig. S4C and D). We realistically assume that lianas have a positive growth rate at least in the absence of herbivores, while trees have a positive growth rate even in the presence of herbivores (SI Appendix, Supplementary Information Text).

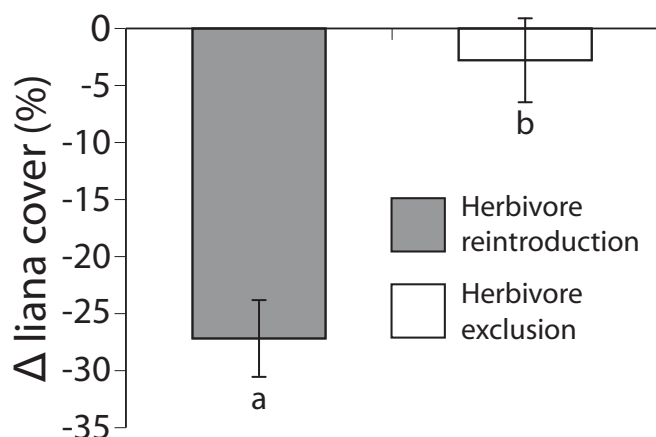


Fig. 3. Effect of herbivore reintroduction on liana cover. Change in liana cover on 50 infested trees (gray bar) following removal of the GLADE—all enclosure fences after 18 y. Control trees ($n = 50$; white bar) were monitored in the nearby UHURU—all enclosures over the same period. Comparison of plot-level changes in liana cover ($n = 2$ plots for GLADE; $n = 3$ plots for UHURU) revealed a significant reduction in liana cover just 2 mo after herbivore reintroduction (ANOVA, $F_{1,3} = 20.48$, $P = 0.020$). Data are means ± 1 SEM.

The model has three nontrivial equilibria: no lianas (All-S); no trees (All-L); and a mixed, endemic equilibrium in which both trees and lianas persist. Thus, as long as trees persist, some fraction will be healthy (i.e., infestation never reaches 100%) because new saplings always start healthy. However, either lianas or trees can be completely absent from the system. This simple model allows analytical treatment of equilibrium stability (*SI Appendix, Supplementary Information Text*). We find that in the absence of herbivory, the endemic equilibrium (illustrated in *SI Appendix, Fig. S4A*) is the only stable one under the following conditions: 1) free-standing lianas have lower per capita fitness than healthy trees; 2) climbers have fast lateral spread; and either 3) free-standing lianas also have lower per capita fitness than infested trees, or 4) free-standing lianas are slow in their lateral vegetative spread (or both 3 and 4). Conversely, the pure-liana equilibrium All-L (illustrated in *SI Appendix, Fig. S4B*) is the only stable one provided either that free-standing lianas have higher per capita fitness than healthy trees or, otherwise, that free-standing lianas have higher per capita fitness than infested trees and both free-standing lianas and climbers have rapid lateral spread (*SI Appendix, Supplementary Information Text*). The All-L scenario seems biologically less likely, yet simulations show that the long-term outcome may not be predictable in the short term (*SI Appendix, Fig. S4B, Inset*).

When the long-term equilibrium is endemic, reintroduction of herbivores can quickly return the system to the preextirpation healthy-tree/no-liana equilibrium if the reintroduced herbivores eat lianas at a similar rate as before. Alternatively, the system can be maintained in an endemic equilibrium with possibly lower liana abundance if the reintroduced herbivores feed less (or less effectively) on lianas (*SI Appendix, Fig. S4 C and D*). We emphasize that the simulations shown in *SI Appendix, Fig. S4* are for illustration only and that the conclusions of our analytical stability analysis do not depend on parameterization.

Discussion

Previous work on herbivore–plant interactions in African savannas has focused almost exclusively on trees and grasses. Our results show that although lianas are scarce in an East African landscape with a largely intact native herbivore community, they can proliferate rapidly in the absence of large herbivores, with deleterious effects on tree growth and reproduction. Native browsers spanning a wide range of sizes and foraging modes—chiefly elephant (up to 5,000 kg), giraffe (~1,000 kg), impala (~50 kg), and dik-dik (~5 kg)—ate *Cynanchum* and contributed in different ways to suppressing its abundance: whereas mega-herbivores could consume considerable biomass and clear large lianas from treetops (Figs. 1 *F* and *H* and 2 *A* and *C* and *SI Appendix, Fig. S1B*), smaller-bodied species were effective at limiting juvenile establishment and prevalence of free-standing lianas in the understory (Fig. 2 *D–F* and *SI Appendix, Fig. S1C*). Our simple, qualitative model of liana spread predicts that in the sustained absence of large herbivores, liana abundance should continue to increase (consistent with experimental results; Fig. 2 *C* and *D* and *SI Appendix, Fig. S1D*) and that endemic liana infestation or even an all-liana state are possible (*SI Appendix, Fig. S4 A and B*). Importantly, however, the ultimate outcome may not be predictable for the first decades (or longer) after the extirpation of herbivores; during the transient period, the system will be in an endemic state (*SI Appendix, Fig. S4 B, Inset*). Thus, the model not only predicts that an all-liana alternative stable state is possible but also suggests that it might not be preceded by any detectable early warning signals.

However, both theoretical (*SI Appendix, Fig. S4 C and D*) and experimental results (Figs. 3 and 4A) also indicate that savannas retain the capacity to recover from severe endemic liana infestation for decades after the loss of large herbivores. These findings are noteworthy in the context of trophic rewilding, which aims to restore ecological processes by reintroducing extirpated megafauna (35). The crucial but uncertain premise of this approach is that such processes are indeed recoverable and that defaunation does not rapidly lead to recalcitrant alternative states. The dramatic recovery observed in our fence-removal experiment—where an already diverse and abundant large-herbivore community halved liana cover in just 2 mo—probably overestimates the rate

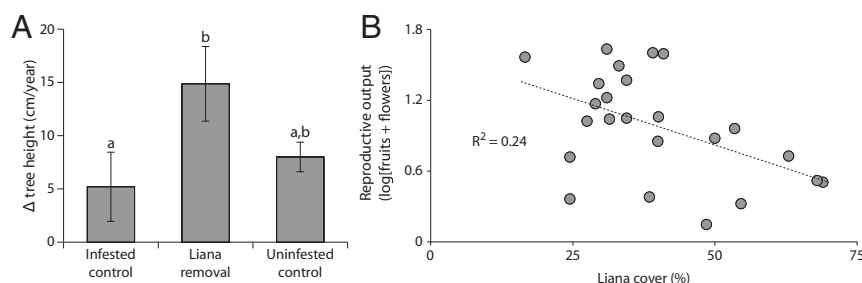


Fig. 4. Effects of liana cover on tree growth and reproductive output. (A) Change in tree (*A. etbaica* and *A. drepanolobium*) height following liana removal ($n = 48$ trees, 16 per treatment; linear mixed-effects model, treatment $\chi^2 = 6.06$, degrees of freedom = 2, $P = 0.048$). Data are means ± 1 SEM; lowercase letters denote significant differences between treatments in post hoc contrasts (Tukey's HSD). (B) Relationship between liana cover and reproductive output (fruits + flowers) for *A. etbaica* ($n = 24$ trees) within UHURU—all enclosures ($F_{1,22} = 6.90$, $P = 0.015$); note log scale on y-axis.

at which lianas would be removed in a system rebounding from large-scale defaunation. Nonetheless, work at larger scales is consistent with our inference that defaunation-induced savanna plant encroachment can be reversed even after decades. In Mozambique's Gorongosa National Park, for example, ungulate populations recovering from near-extirpation have reasserted biotic control over the invasive shrub *Mimosa pigra* (36).

Our results also highlight the lack of functional redundancy among wild browsers of different sizes (Fig. 2 and *SI Appendix, Fig. S1 A–C*), as well as between wild and domesticated browsers: even goats and camels ate *Cynanchum* rarely relative to the most abundant wild browsers (Fig. 1 *E* and *F*), and previous studies have noted “the dislike of livestock for [*C.*] *viminale*” (34, p. 121). This pattern underscores the importance of conserving functionally diverse native assemblages and is consistent with a previous study at Mpala showing that the diversity of native large herbivores was important in reducing encroachment by the shrub *Solanum campylacanthum* (37). Notably, the toxicity of secondary metabolites in both of these plants appears to be greater for domesticated than wild ungulates (28, 38). The glycosides in *Cynanchum* cause a potentially lethal poisoning syndrome (cynanchosis) that affects farmed cattle, goats, sheep, horses, and ostriches in southern Africa (39–41) and may be a particular risk to naïve livestock (e.g., ref. 42). Although livestock may be functional proxies for wildlife in certain respects (7), there is growing evidence that replacement of native herbivore guilds with (invariably less species-rich and functionally diverse) livestock has altered plant communities and disrupted ecosystem processes in African savannas (43, 44). *Cynanchum*'s toxicity to domesticated ungulates, its competitive effects on trees (Fig. 4) and perhaps grasses (*SI Appendix, Figs. S1 and S2*), and its ability to form dense mats that reduce access to forage plants and increase the odds of accidental ingestion all suggest that removing native browsers might limit the productivity and profitability of both grazing and browsing livestock. Explicit investigation of this possibility would be useful.

Our simple theoretical model omits several fundamental savanna processes (e.g., tree–grass interactions, rainfall, fire), as well as nuances such as potential effects of tree and herbivore species composition. Accordingly, and because we lack empirically validated parameter estimates, we do not use the model for quantitative prediction. Rather, the model provides an analytically tractable heuristic tool for qualitative insight into possible outcomes of liana–tree interactions on long timescales and the conditions associated with alternative stable states. The all-liana state minimally requires high per capita fitness of free-standing lianas, and although free-standing lianas do reproduce, we consider this condition relatively unlikely (perhaps explaining why we are unaware of any savanna dominated by vines to the exclusion of trees). The more likely endemic equilibrium matches the scenario in –all enclosures maintained for up to 17 y, and the predicted reversibility of this scenario back to an essentially all-tree state accords with our data—yet our data also show that liana prevalence in –all enclosures was increasing exponentially after more than a decade (*SI Appendix, Fig. S1D*), indicating that no stable state has been reached. We hope that our model will stimulate further research on the long-term consequences of liana encroachment in megafauna-free savannas.

The marginal effect of herbivore exclusion on total tree density in the 12 southern UHURU plots (Fig. 2*B*) was useful in showing that liana abundance did not simply track tree density across treatments but is surprising in light of previous enclosure studies documenting stronger effects over comparable time-spans. In the GLADE experiment, for example, tree density was roughly threefold greater in enclosures than unfenced plots after 10 y (45, 46). The treatment effect on tree biomass in UHURU was more pronounced than that on overall density, reflecting the greater number of large trees in (especially –meso) enclosures, yet the persistent lack of difference between –all and +all plots

remains puzzling. Although it is tempting to speculate that competition with *Cynanchum* in –all plots might have something to do with this unexpected null result, the previous findings from GLADE (where liana prevalence was also high: Fig. 2 *C* and *D*) seem at odds with this interpretation. A fuller investigation of tree dynamics in UHURU is needed.

In several respects, our results are broadly consistent with patterns reported from Neotropical forests, where the majority of liana research has occurred to date (but see ref. 47). For example, we found evidence that liana infestation reduces tree fitness and that this effect is correlated with infestation severity (Fig. 4), mirroring findings from Panama and Bolivia (48, 49). In both forest and savanna, the distribution and abundance of lianas is also linked to the availability of trellises, and the rate of spread of lianas between tree canopies is strongly influenced by the proximity of neighboring trees (Fig. 2 *E* and *F*; ref. 50). There are also similarities between the all-liana state that our model suggests is possible in savannas and the “stalled gap” phenomenon in tropical forests, where dense liana tangles arrest succession in treefall gaps (18). These similarities notwithstanding, the major differences between Neotropical forests and African savannas (climate, tree diversity and structure, liana traits, disturbance regimes) dictate caution in attempting cross-biome comparisons; deeper insights will require a better understanding of the drivers of liana abundance in savannas and savanna–forest mosaics. Chief among the unknowns are the susceptibility of lianas to fire (which is infrequent in many dry savannas, including Mpala, but is a dominant force in the savanna biome more broadly), the role of water-limitation in liana recruitment and survival, and the vulnerability of dominant liana species to herbivory.

Predicting how savanna plant communities are likely to change over the next century—and how those changes will affect ecologically and economically important ecosystem processes—is an important goal at the nexus of ecology and conservation (3). Presently, the integration of lianas into savanna vegetation models is precluded by a paucity of information about the diversity, distribution, and ecology of this life-form, even at the coarsest spatial and temporal scales. A first step in this regard is to catalog the distribution and abundance of lianas across the continent (21), with particular attention to forest–savanna transitions where significant shifts in floristic composition have already occurred—and where, intriguingly, liana encroachment into grasslands has been documented in conjunction with reductions in herbivore density (51). The concerted effort to understand how liana abundance and diversity have changed over recent decades in Neotropical forests provides a roadmap for similar efforts in savannas. A comparative, multi-biome approach to liana ecology has the potential to deepen our understanding of forests and savannas while extending our ability to effectively manage and conserve them.

Materials and Methods

Study Site and Long-Term Herbivore Enclosure Experiments. Mpala encompasses 20,000 ha of semiarid thorn-scrub savanna (Fig. 1). The study area is underlain by infertile red sandy loams. The woody-plant community is dominated by spinescent *Acacia s.l.* (including *Senegalia* and *Vachellia* spp.) trees and shrubs—predominantly *A. (S.) brevispica*, *A. (V.) etbaica*, and *A. (S.) mellifera*, with several other species occurring more patchily. The understory comprises several hundred species of grasses, forbs, and subshrubs (26, 52, 53). Elephant (*Loxodonta africana*), impala (*Aepyceros melampus*), dik-dik (*Madoqua cf. M. guentheri*), plains zebra (*Equus quagga*), and giraffe (*Giraffa camelopardalis*) account for the majority of native large-herbivore biomass (54). Controlled burns are not used for management, and unintentional fires are infrequent, in part because understory biomass is low and interspersed with patches of bare soil (25), in part because the trimodal annual rainfall pattern with a short (~3 mo) dry season limits fuel accumulation, and in part because property managers practice preventative measures.

Although African lianas are comparatively little studied (55), >2,200 species of lianas and vines have been cataloged continent-wide; diversity is highest in forested parts of West and Central Africa, but most savanna-

dominated stretches of East Africa also support at least 5 to 10 liana species (21). *Cynanchum viminale* is the most abundant scandent plant native to Mpala (others include a closely related but much rarer congener, *Cynanchum gerrardii*, along with herbaceous *Plectranthus* and *Kleinia* spp.) and is widespread throughout Africa, Asia, and Australia. In this range, *C. viminale* occurs in habitats ranging from dry scrub to forest; in savannas, it is common in thickets, where it adopts a climbing habit (56), and in the absence of support it forms a short shrub (39). Like many succulent lianas, *C. viminale* reproduces sexually by wind-dispersed seeds and clonally from root and stem fragments, with laterally growing stems forming adventitious roots where they touch the ground—a suite of traits that facilitates rapid expansion (34).

The GLADE experiment (25) comprised six paired 70 × 70 m total exclosures and unfenced control plots (Fig. 1D), three each in bushy habitat and anthropogenic clearings (glades). Exclosures consisted of wire-mesh fencing from 0 to 50 cm and 11 strands of electrified wires up to 3 m, excluding all mammalian herbivores ≥ 5 kg (i.e., dik-dik and everything larger). Fences in the three bushy replicates were maintained from 1999 until mid-2017, when they were removed. The UHURU experiment comprises nine replicate blocks of four treatments (Fig. 1C), three blocks each in southern, central, and northern Mpala (57). Total exclosures (–all), directly analogous to the GLADE exclosures, are surrounded by 1-m tall mesh fences and electrified wires up to 2 m, excluding all herbivores ≥ 5 kg. Mesoherbivore exclosures (–meso) consist only of electrified wires and lack mesh, allowing access to herbivores < 50 cm tall; thus, the difference between –all and –meso is effectively the presence of dik-dik, the smallest and most abundant ungulate at Mpala. Megaherbivore exclosures (–mega) consist of electrified wires at 2 m, allowing access to all herbivores except elephant and giraffe; thus, –meso and –mega differ in the presence of multiple ungulate species, but of these, impala are ~15-fold more abundant than any other and account for more biomass than all others combined (54). Unfenced open plots (+all) are marked with wooden posts and are freely accessible to all species. The impact of each herbivore size class can thus be assessed by comparing UHURU treatment pairs, while the net impact of successively larger-bodied herbivore groups can be assessed by comparing each treatment to +all (57).

Consumption of Lianas by Large Herbivores. We used DNA metabarcoding data from 1,322 fecal samples of 33 herbivore species collected at Mpala from 2013 to 2016, which we made publicly available with previous studies (30, 32). Detailed methods are in the original sources. Briefly, for each of the 20 most abundant large-herbivore species, we analyzed data from 6 to 163 fecal samples per species (total $n = 1,176$; *SI Appendix, Tables S1 and S2*). DNA metabarcoding used the *trnL*-P6 chloroplast marker. Samples were rarefied to an even sequencing depth, and taxonomic assignments were based on a comprehensive reference library of *trnL*-P6 sequences from locally collected and taxonomically verified specimens (53). These data could not differentiate the two *Cynanchum* species at Mpala, *C. viminale* and *C. gerrardii*, which share the same barcode (along with similar ecological habits); plant surveys in UHURU prior to 2014 likewise lumped these taxa, but subsequent data show that *C. viminale* is ~100-fold more abundant than *C. gerrardii*. We calculated two complementary metrics of interaction intensity. Relative read abundance is the mean percentage of plant DNA sequence reads per sample that matched *Cynanchum* and is considered a reasonable proxy for proportional consumption in analyses of herbivore diets based on the *trnL*-P6 marker. Frequency of occurrence is the percentage of samples that contained *Cynanchum*—a presence–absence metric where relative read abundance ≥ 0.1% was interpreted as evidence of presence.

To test which herbivores might eat *C. viminale* if it were more available, we transplanted entire lianas from 14 trees in –all plots onto size-matched conspecific trees outside exclosures. We weighed lianas immediately before transplanting and reweighed the remaining unconsumed biomass again between 4 and 20 d later, after some noticeable fraction of the liana had disappeared (mean trial duration: 9.8 d). We used Bushnell TrophyCams to determine which herbivore species ate transplanted lianas. To estimate weight loss attributable to desiccation alone, we transplanted five lianas from their host trees onto other trees inside a fenced exclosure, weighing before transplanting and again after 10 d to match the mean duration of the herbivory trials.

Effects of Herbivore Exclusion on Liana Infestation. To test the hypothesis that severity and frequency of liana infestation increases as browsing pressure decreases, we conducted several surveys in UHURU in January 2017. First, we haphazardly identified 1,150 trees (~100 per plot; mean height 3.1 m) and recorded the number of individual (separately rooted) *Cynanchum* on each, as well as the areal percentage of each canopy covered. We used the same

data to estimate the proportion of trees infested by at least one liana in each plot. These data were averaged within each plot and analyzed with separate one-factor ANOVA, with exclosure treatment as the factor, in R [version 3.3.2 (58)]. We surveyed juvenile (<1-m tall) *C. viminale* along four 50 × 4 m transects per plot to test the hypothesis that liana recruitment varies as a function of herbivore-exclusion treatment. Transects were aligned with a permanent grid of 49 metal stakes in the central 60 × 60 m of each plot (57). Because trees have previously been shown to provide associational refuges from herbivores at Mpala (26), we separately compared juvenile *Cynanchum* growing 1) beneath tree canopies and 2) in open habitat between trees; data were again averaged at the plot level and analyzed with one-factor ANOVA as functions of treatment.

To measure liana growth rates, we marked the terminal 10 cm on each of 10 haphazardly selected branches on 10 *C. viminale* in each UHURU plot in August 2016 ($n = 10$ stems/plant × 10 plants/plot × 12 plots). We remeasured and calculated mean growth rate per plant in January 2017 ($n = 117$ of the original 120 plants); we then averaged plant-level data per plot and compared annualized growth rates across treatments with ANOVA.

To determine tree density in UHURU, we recorded the number and identity of all trees (binned into height classes) in 10 × 10 m subsections of each plot in each year from 2016 to 2018 (up to 36 subplots per plot, although not all subplots were surveyed in each year). To obtain a single time-integrated plot-level value of tree density (>1-m tall) for analysis, we first averaged across subplots in each plot in each year and then averaged these means across the 3 y. To estimate the total number of infested trees in each plot, we multiplied plot-level tree densities by the proportion of trees infested per plot. To estimate tree biomass per plot, we used data from 3,281 permanently tagged trees in UHURU that were measured at least once between 2009 to 2018 (57). We calculated biomass as a function of crown diameter (CD, average of the widest canopy axis and its perpendicular, in m) using the following equation (59):

$$\text{Mass in kg} = (7.49 \times \text{CD}) - 7.76.$$

This equation has been used in previous studies from Mpala (25, 45, 46). We then regressed these biomass estimates as a function of height (H , in m) of the same tagged trees, yielding the following linear regression ($R^2 = 0.69$, $F_{1,3279} = 7224$, $P < 0.0001$):

$$\text{Mass in kg} = (9.093 \times H) - 9.10.$$

For this same set of permanently tagged trees (57), we calculated the mean height (in 2015) for each of the size classes used in the annual censuses of tree density described above: 1 to 2 m (1.61 m), 2 to 3 m (2.52 m), 3 to 4 m (3.48 m), and >4 m (4.69 m). We plugged these mean height values into the regression of biomass as a function of H , multiplied by the mean density of trees in each size class per plot (calculated as described above for total density), and summed these products across height classes to obtain biomass per plot. We note that the series of conversions and approximations used to estimate biomass inevitably introduces error; thus, although we are confident in the relative comparison of biomass among treatments in UHURU, the absolute values should be regarded with caution. We analyzed tree density and biomass using one-factor ANOVA.

To quantify relative abundance of *Cynanchum* in the plant community and test for differences in height across treatments, we used data from a canopy-intercept survey (60) in November 2018. At each of the 49 grid stakes in each plot, we placed a telescoping pole on the ground and extended it upwards. We recorded the number of contacts between plants and pole and the species and height of each hit (0 to 600 cm, encompassing the full range of heights accessible to browsers from dik-dik to giraffe). We analyzed *Cynanchum* pin hits (total and as percent of all species) and mean *Cynanchum* height using one-factor ANOVA by treatment on square-root-transformed data (excluding the +all treatment from the height analysis, as *Cynanchum* accounted for just three total pin hits in just two +all plots). To assess *Cynanchum* in the understory, we used a similar canopy-intercept approach, but with a 10-pin frame at each grid stake ($n = 490$ pin placements per plot) in each of 20 surveys from 2008 to 2019 (57). We fit an exponential-growth model to mean *Cynanchum* prevalence in the understory of –all plots across surveys. We conducted these canopy-intercept surveys in all 36 UHURU plots (as opposed to just the 12 southern plots used for the other surveys in this study) and lumped *C. viminale* and *C. gerrardii* (which we did not distinguish in understory surveys prior to 2014), but *C. viminale* accounted for 99% of pin hits in both survey types such that *C. gerrardii* did not influence the overall pattern.

Effects of Herbivore Reintroduction on Liana Cover. We measured percent cover of lianas on 50 haphazardly selected trees within the GLADE –all

exclosures in August 2016 (before fence removal) and again in July 2017 (~2 mo after fence removal). For comparison, we selected 50 trees from the UHURU –all plots and measured change in liana cover from June 2016 to June 2017. We averaged data within each plot ($n = 2$ plots for GLADE, $n = 3$ plots for UHURU) and compared the change in liana cover between deconstructed and intact exclosure experiments with one-factor ANOVA.

Effects of Liana Infestation on Trees. In June 2016, we identified 30 liana-infested and 15 uninfested *Acacia* trees within the UHURU –all and –meso exclosure plots and divided them into 15 triplets of nearby individuals matched by species (*A. etbaica* or *Acacia drepanolobium*) and height (as closely as possible; mean height disparity 0.46 m). In each triplet, we randomly assigned one infested tree to a liana-removal treatment, which involved manually removing all lianas from the canopy and trunk; the average weight of lianas removed from each tree was 14.1 ± 4.2 kg. We left the other two trees in each triplet as infested and uninfested controls. We measured tree heights after the manipulation (to account for any immediate physical rebound) and again in June 2017. We analyzed change in tree height using a linear mixed-effects model, with treatment as the main effect and triplet identity as a random effect; we estimated the P value using a likelihood-ratio test and used Tukey's honestly significant difference (HSD) to contrast each pair of treatments.

In January 2017, we assessed the impact of liana infestation on tree reproduction by surveying liana loads on 24 reproductive *A. etbaica* in UHURU –all plots (to control for the effect of herbivory on reproductive output; ref. 61). For each tree, we haphazardly placed 10 quadrats (50 × 50

cm) on the canopy and recorded the mean number of tree reproductive units (fruits and flowers) and mean percent liana cover. We used linear regression to assess the correlation between liana cover and reproductive output per tree (after log-transforming reproductive output to meet the assumption of normality).

Data Availability. Data from this study are available in Dryad Digital Repository, <https://doi.org/10.5061/dryad.gmsbcc2np> (62). Original DNA-metabarcoding data are also available in Dryad, <https://doi.org/10.5061/dryad.c119gm5> (63).

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Supplementary Information for

Large herbivores suppress liana infestation in an African savanna

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This PDF file includes:

- Supplementary text
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- Legends for Movies S1 to S4
- List of data deposited in Dryad
- SI References

Other supplementary materials for this manuscript include the following:

- Movies S1 to S4

Supplementary Information Text

Theoretical model description. We built a simple ordinary differential equations model to capture the dynamics of tree and liana densities. Trees and free-standing lianas compete for the available space (given by the tree-carrying capacity K , or the liana-carrying capacity K/η). Trees can be either healthy (S) or infested (I), and lianas can be found either free-standing (L) or growing on trees (henceforth, climbers). In the latter case, for simplicity, we assume that only one liana will occupy a tree. Consequently, lianas growing on trees are implicitly accounted for in the model via their hosts and, once a tree is infested, additional lianas that might climb it do not change its degree of infestation: i.e., they are assumed to either outcompete the predecessor or die.

We modeled infestation as a contagion process in which both free-standing and climbing lianas can spread to and infest healthy trees. Free-standing lianas and climbers both produce seeds (at rates ρ_L and ρ_I , respectively) that are wind-dispersed and therefore assumed to be randomly scattered across the landscape. Germinating seeds give rise to free-standing lianas; we assume that these (like *Cynanchum*) can grow adventitious roots, and thus vegetatively grow laterally until they encounter a tree that they can climb (regardless of how far away that tree is). Thus, we assume that infestation by free-standing lianas is a density-dependent process, reflected in a transmission probability β that encompasses dispersal of seeds and vegetative spread of free-standing lianas. Climbers can cause new infestations via lateral spread at rate $c\tilde{\beta}$ to neighboring, possibly healthy trees. Thus, we assume that direct infestation by climbing lianas is a frequency-dependent process. We further assume that both seed production and vegetative growth are higher for climbers than for free-standing lianas; conversely, consistent with our empirical observations, infested trees have lower reproduction and higher mortality. Free-standing lianas and climbers naturally die at rates δ_L and δ_I , respectively, both of which are enhanced by the presence of herbivores, h_L .

Healthy and infested trees reproduce and naturally die at possibly different rates (r_S and r_I , d_S and d_I , respectively) and their natural mortality is augmented by herbivore-induced mortalities, h_S and h_I , respectively.

$$\frac{dS}{dt} = (r_S S + r_I I) \left(1 - \frac{S + (1 + \eta)I + \eta L}{K} \right) + (\delta_I + h_L)I - (d_S + h_S)S - c\tilde{\beta} \frac{SI}{S + (1 + \eta)I + \eta L} - \beta SL$$

$$\frac{dI}{dt} = c\tilde{\beta} \frac{SI}{S + (1 + \eta)I + \eta L} + \beta SL - (\delta_I + h_L)I - (d_I + h_I)I$$

$$\frac{dL}{dt} = (\rho_L L + \rho_I I) \left(1 - \frac{S + (1 + \eta)I + \eta L}{K} \right) + d_I I - (\delta_L + h_L)L - \beta SL - \beta IL$$

Model Analysis. There are four equilibria: the trivial one $(0,0,0)$, a mixed or endemic equilibrium (S^*, I^*, L^*) , and two pure equilibria, All-S = $(K(1 - (d_S + h_S)/r_S), 0, 0)$ and All-L = $(0, 0, K/\eta(1 - (\delta_L + h_L)/\rho_L))$. Realistically, we assume that trees have a positive growth rate, both in the presence and in the absence of herbivores (i.e., $r_S > d_S + h_S$), and that lianas have a positive growth rate at least in the absence of herbivores (i.e., $\rho_L > \delta_L$). This makes the trivial equilibrium unstable; consequently, below we analyze the stability of the non-trivial equilibria. The endemic equilibrium is stable when neither All-L nor All-S is stable.

All-L is stable if the growth rate of free-living lianas is positive

$$\rho_L > \delta_L + h_L \quad (1)$$

and:

- a) either the per capita fitness of free-standing lianas exceeds that of healthy trees

$$\frac{\rho_L}{\delta_L + h_L} > \frac{r_S}{d_S + h_S} \quad (2)$$

- b) or, otherwise, the per capita fitness of free-standing lianas exceeds that of infested trees

$$\frac{r_S}{d_S + h_S} > \frac{\rho_L}{\delta_L + h_L} > \frac{r_I}{d_I + h_I} \quad (3)$$

and, in that case, the lateral spread of free-standing lianas must also be sufficiently high

$$\frac{\beta L^*}{\delta_I + d_I + h_I + h_L} > \frac{(\delta_L + h_L)r_S - (d_S + h_S)\rho_L}{(d_I + h_I)\rho_L - (\delta_L + h_L)r_I} \quad (4)$$

All-S is stable if:

- a) either the per capita fitness of healthy trees exceeds that of free-standing lianas

$$\frac{\rho_L}{\delta_L + h_L} < \frac{r_S}{d_S + h_S} \quad (5)$$

and, in that case, the expected number of trees infected via lateral spread by the first climber in the population must also be less than one

$$\frac{c\tilde{\beta}}{\delta_I + d_I + h_I + h_L} < 1 \quad (6)$$

- b) or, otherwise, the per capita fitness of free-standing lianas must exceed that of climbers

$$\frac{r_S}{d_S + h_S} > \frac{\rho_L}{\delta_L + h_L} > \frac{\rho_I}{\delta_I + h_I + h_L} \quad (7)$$

and, in addition, there is a lower bound¹ on β and an upper bound² on $\tilde{\beta}$. We assume that this case is not realistic in our system as it amounts to climbing being a bad life-history strategy for lianas, inconsistent with observations.

We want to find the conditions under which, in the presence of herbivory, All-S is stable, while in the absence of herbivory All-S is not stable and All-L either (i) is stable (in which

¹ $\frac{\beta S^*}{\delta_I + d_I + h_I + h_L} > \frac{(d_S + h_S)\rho_L - r_S(\delta_L + h_L)}{(\delta_I + h_I + h_L)r_S - (d_S + h_S)\rho_I}$

² $c\tilde{\beta} < \frac{-(\delta_I + d_I + h_I + h_L)((d_S + h_S)\rho_L - r_S(\delta_L + h_L)) + \beta S^*((d_I + h_I + h_L)r_S - (d_S + h_S)\rho_I)}{\beta K(r_S - d_S - h_S) + (\delta_L + h_L)r_S - (d_S + h_S)\rho_L}$

case the system ends up with only lianas) or (ii) is unstable (in which case the system ends up in the endemic equilibrium).

In the presence of herbivores, for All-S to be stable both eqns. (5) and (6) must hold: the per capita fitness of trees exceeds that of free-standing lianas and the expected number of trees infected via lateral spread by the first climber in the population is less than one (in other words, the R_0 of the infestation is less than one).

In the absence of herbivores, for All-S to be unstable at least one of eqns. (5) or (6) must be violated, i.e.:

- a) either the per capita fitness of free-standing lianas exceeds that of healthy trees (i.e. $\rho_L/\delta_L > r_S/d_S$), in which case **All-L is the only stable equilibrium**
- b) or, if not, then the expected number of trees infected via lateral spread by the first climber in the population must be at least one (i.e. $c\tilde{\beta}/(\delta_I + d_I) \geq 1$). In this case, which equilibrium is stable depends on eqn. (1), which is true by our assumption, and on eqns. (3) and (4):
 - i. if at least one of them does not hold, i.e., the per capita fitness of free-standing lianas is lower than that of infested trees ($\rho_L/\delta_L \leq r_I/d_I$) or free-standing lianas are limited in their vegetative spread (i.e., β not too high), then **the only stable equilibrium is the endemic (mixed) one**.
 - ii. if both hold, then **All-L is the only stable equilibrium**.

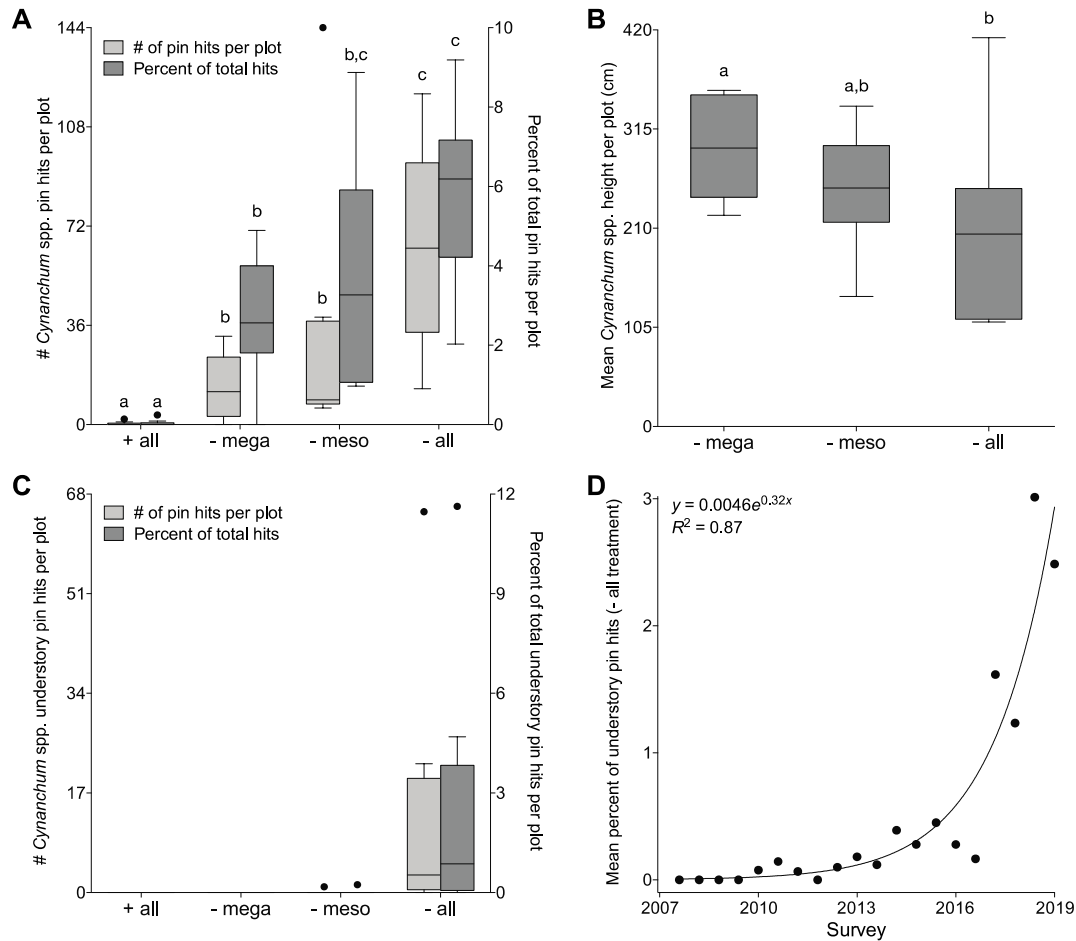


Fig. S1. Liana infestation in overstory and understory after 10 yr of herbivore exclusion. (A) Prevalence of *Cynanchum* spp. across treatments in November 2018. Tukey plots (boxes, median and IQR; whiskers up to $\pm 1.5 \times \text{IQR}$; points, outliers) show summed *Cynanchum* spp. pin hits per plot (left y-axis) and as a percentage of total pin hits across all species (right y-axis). Connecting letters denote significant differences ($P \leq 0.05$) among treatments in Tukey's HSD contrasts from one-way ANOVA on square-root-transformed data ($n = 9$ plots per treatment, 49 pin placements per plot; $F_{3,32} = 18.16$, $P < 0.0001$ for summed pin hits and $F_{3,32} = 26.85$, $P < 0.0001$ for percent). (B) Mean height of *Cynanchum* spp. pin hits in the fenced enclosure treatments in November 2018; the +all treatment is excluded because *Cynanchum* spp. were recorded in just 2 of 9 plots (with just 2 and 1 total pin hits in those plots). Boxplot conventions as in A; connecting letters denote significant differences among treatments in Tukey's HSD contrasts from one-way ANOVA on square-root transformed data ($F_{2,23} = 3.59$, $P = 0.044$). (C) Prevalence of *Cynanchum* spp. in the understory of each treatment in February 2019; boxplot conventions as in A ($n = 9$ plots per treatment, 49 placements of a 10-pin frame per plot), showing that *Cynanchum* occurred in the understory exclusively in -all plots (up to 12% of pin hits, mean 2.5%). (D) In -all plots, prevalence of *Cynanchum* in the understory increased exponentially from October 2008 to February 2019. Points are means across the 9 -all plots in each of 20 semi-annual surveys (wet and dry seasons); exponential growth model (x is survey number, 1–20) and R^2 are at top left. All panels lump *C. viminale* and *C. gerrardii*; the former accounted for >99% of pin hits in both overstory and understory.





Fig. S2. *Cynanchum* infestation in UHURU -all plots, March 2021. (A) Reproductive free-standing liana, *C. viminalis*, in the understory (note dehiscent seed pods). (B) Juvenile lianas recruiting in near-monoculture under tree canopy. (C) Lianas recruiting in near-monoculture under bunchgrass canopy, with current year's white-plumed seeds covering the ground. (D) Free-standing lianas overtopping grasses in the understory (foreground) and large *Acacia* (*Vachellia*) *etbaica* (background). (E) Reproductive lianas dominating both the understory (foreground) and tree canopies (top left and center). (F) Trees completely covered by lianas. (G) *Acacia* (*Vachellia*) *drepanolobium* tree top-killed under heavy liana cover.

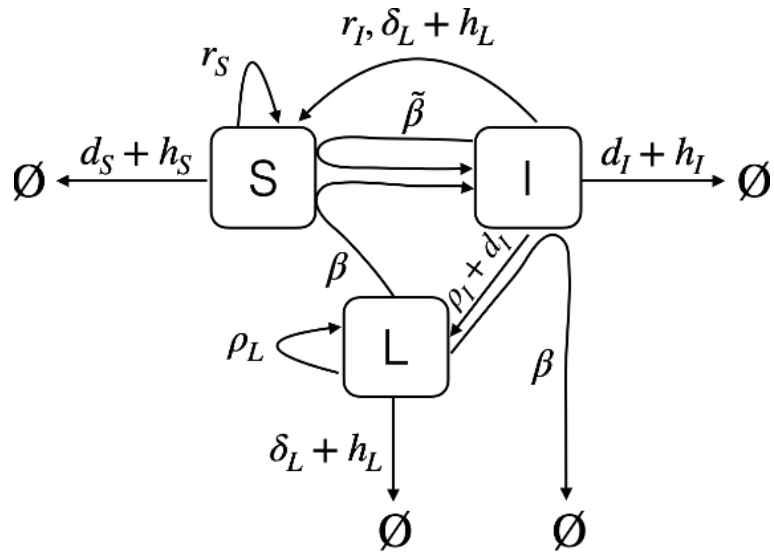


Fig. S3. Model schematic. See Supplementary text (*Theoretical model description*) for parameter definitions.

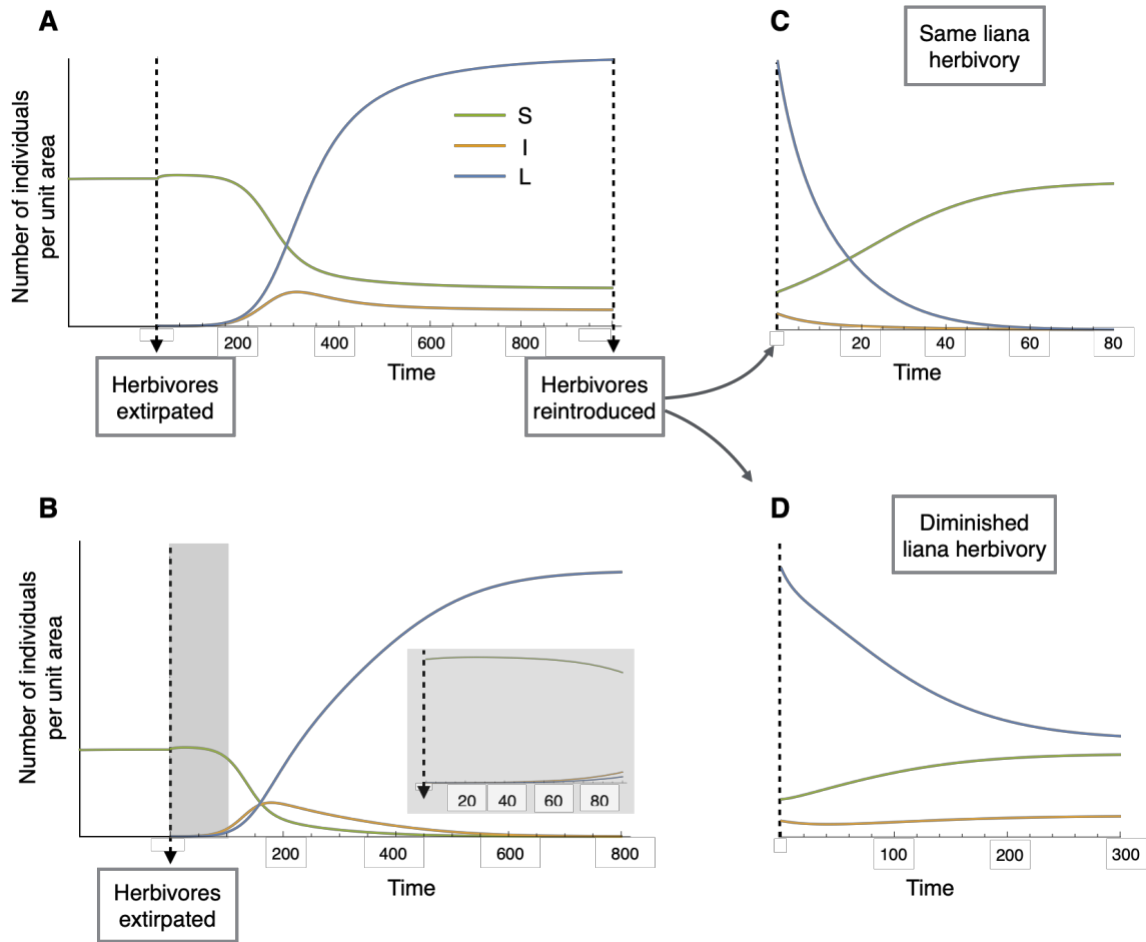


Fig. S4. Illustrative model predictions of long-term liana-tree dynamics following herbivore extirpation and subsequent reintroduction. A system with vanishingly few lianas in the presence of herbivores can end up in **(A)** an endemic equilibrium in the absence of herbivores or **(B)** an alternative, all-liana state; inset shows close-up of the first 100 years after the extirpation of herbivores corresponding to the grey region in (B). **(C,D)** Effects of reintroducing herbivores on the endemic equilibrium in (A) if the restored herbivore assemblage feeds on the lianas at **(C)** the same rate or **(D)** a lower rate than the pre-extirpation assemblage. Parameters: (A) $\beta = 0.00001$; (B) $\beta = 0.0001$; when herbivores are present in (A,B), $h_S = 0.002$, $h_L = 0.1$, and $h_I = 0.01$; (C,D) same parameters as in (A) with herbivory, except in (D) $h_L = 0.01$. Across all panels, the remaining parameters are: $K = 500$, $\eta = 0.3$, $r_S = 0.1$, $d_S = 0.01$, $r_I = 0.05$, $d_I = 0.025$, $\rho_L = 0.1$, $\delta_L = 0.02$, $\rho_I = 0.3$, $\delta_I = 0.01$, $c = 6$, $\tilde{\beta} = 0.01$. Carrying capacity is measured in individuals per unit area. All rates are per year; transmission rates are in meters per year. We selected parameters solely for exemplification, loosely informed by field intuition and (for healthy trees) by previous demographic work at Mpala; we emphasize that our model-based inferences do not depend on parameterization or the illustrative simulations shown here.

Table S1. Summary data on *Cynanchum* consumption by herbivore species. Shown for each of the 20 most common large-herbivore species in our study area are the number of fecal samples analyzed with DNA metabarcoding (*n*), the mean and SEM relative read abundance (RRA) of *Cynanchum* DNA sequences in samples from that species, the maximum *Cynanchum* RRA present in any individual sample from that species, the number of samples in which *Cynanchum* DNA was present (at $\geq 0.1\%$ RRA), and the frequency of occurrence (FOO) of *Cynanchum* DNA in samples for that species. Species are listed from top to bottom in decreasing order of mean RRA. The RRA and FOO data match those shown in Fig. 1 of the main text. Sample-specific data are in Table S2.

Species	Latin name	Type	<i>n</i>	Mean RRA (%)	SEM RRA	Maximum individual RRA	<i>n</i> samples present	FOO (%)
Dik-Dik	<i>Madoqua cf. M. guentheri</i>	Wild	120	0.35%	0.076%	5.2%	60	50.0%
Giraffe	<i>Giraffa camelopardalis</i>	Wild	58	0.29%	0.055%	2.5%	37	63.8%
Bushbuck	<i>Tragelaphus scriptus</i>	Wild	12	0.22%	0.030%	0.4%	11	91.7%
Elephant	<i>Loxodonta africana</i>	Wild	80	0.19%	0.055%	3.7%	37	46.3%
Kudu	<i>Tragelaphus strepsiceros</i>	Wild	28	0.13%	0.026%	0.5%	16	57.1%
Impala	<i>Aepyceros melampus</i>	Wild	129	0.11%	0.037%	4.5%	40	31.0%
Waterbuck	<i>Kobus defassa</i>	Wild	6	0.10%	0.026%	0.2%	5	83.3%
Goat	<i>Capra hircus</i>	Domestic	19	0.06%	0.019%	0.3%	8	42.1%
Eland	<i>Taurotragus oryx</i>	Wild	54	0.04%	0.017%	0.7%	10	18.5%
Camel	<i>Camelus dromedarius</i>	Domestic	39	0.04%	0.011%	0.3%	12	30.8%
Cattle	<i>Bos taurus</i>	Domestic	163	0.04%	0.007%	0.5%	32	19.6%
Sheep	<i>Ovis aires</i>	Domestic	48	0.03%	0.010%	0.3%	10	20.8%
Oryx	<i>Oryx beisa</i>	Wild	22	0.03%	0.012%	0.2%	5	22.7%
Warthog	<i>Phacochoerus africanus</i>	Wild	30	0.02%	0.010%	0.2%	5	16.7%
Buffalo	<i>Syncerus caffer</i>	Wild	92	0.02%	0.007%	0.4%	11	12.0%
Hippo	<i>Hippopotamus amphibius</i>	Wild	23	0.02%	0.009%	0.1%	5	21.7%
Hartebeest	<i>Alcelaphus buselaphus</i>	Wild	27	0.02%	0.009%	0.2%	4	14.8%
Grevy's zebra	<i>Equus grevyi</i>	Wild	91	0.02%	0.006%	0.4%	10	11.0%
Donkey	<i>Equus asinus</i>	Domestic	29	0.01%	0.008%	0.2%	3	10.3%
Plains zebra	<i>Equus quagga</i>	Wild	106	0.01%	0.003%	0.3%	5	4.7%

Table S2. Data on *Cynanchum* consumption for each individual fecal sample.

Shown for each of the 1,176 fecal samples analyzed with DNA metabarcoding are the herbivore species, sample ID assigned at collection, relative read abundance (RRA) of *Cynanchum* DNA (here as proportion rather than percent), whether *Cynanchum* was present (1) or absent (0) from the sample, date of sample collection, collection location (decimal degrees), and total sequence read depth. Full information on the production and curation of these data is in references S1–S3.

	Species	SampleID	RRA	Present?	Sample Date	Longitude	Latitude	Read depth
1	Buffalo	WAT204	0.004	1	3/12/15	36.91	0.29	14406
2	Buffalo	BUF209	0.003	1	3/13/15	36.89	0.29	11736
3	Buffalo	WAT203	0.003	1	3/12/15	36.91	0.29	2145
4	Buffalo	BUF18	0.002	1	7/10/13	36.91	0.34	12785
5	Buffalo	BUF204	0.002	1	3/8/15	36.86	0.30	24595
6	Buffalo	WAT202	0.002	1	3/12/15	36.91	0.29	2092
7	Buffalo	BUF207	0.001	1	3/10/15	36.91	0.32	16156
8	Buffalo	BUF211	0.001	1	3/13/15	36.89	0.28	18866
9	Buffalo	BUF221	0.001	1	3/18/15	36.91	0.28	13511
10	Buffalo	WAT205	0.001	1	3/12/15	36.91	0.29	1930
11	Buffalo	WHO206	0.001	1	3/16/15	36.91	0.29	75710
12	Buffalo	BUF01	0.000	0	6/26/13	36.89	0.35	12507
13	Buffalo	BUF02	0.000	0	6/26/13	36.89	0.35	31455
14	Buffalo	BUF03	0.000	0	6/26/13	36.89	0.36	18924
15	Buffalo	BUF04	0.000	0	6/27/13	36.93	0.37	7013
16	Buffalo	BUF05	0.000	0	6/27/13	36.87	0.38	14076
17	Buffalo	BUF06	0.000	0	6/28/13	36.89	0.28	8983
18	Buffalo	BUF07	0.000	0	7/3/13	36.90	0.29	9372
19	Buffalo	BUF08	0.000	0	7/3/13	36.90	0.29	8999
20	Buffalo	BUF09	0.000	0	7/4/13	36.89	0.29	6002
21	Buffalo	BUF10	0.000	0	7/4/13	36.88	0.32	8464
22	Buffalo	BUF101	0.000	0	10/27/14	36.87	0.36	145646
23	Buffalo	BUF102	0.000	0	10/27/14	36.86	0.30	119633
24	Buffalo	BUF103	0.000	0	10/28/14	36.92	0.38	78795
25	Buffalo	BUF104	0.000	0	11/1/14	36.90	0.30	109818
26	Buffalo	BUF105	0.000	0	11/2/14	36.88	0.29	65858
27	Buffalo	BUF106	0.000	0	11/3/14	36.91	0.32	72386
28	Buffalo	BUF107	0.000	0	11/3/14	36.92	0.35	31447
29	Buffalo	BUF108	0.000	0	11/4/14	36.91	0.31	70533
30	Buffalo	BUF109	0.000	0	11/4/14	36.91	0.31	108630
31	Buffalo	BUF11	0.000	0	7/5/13			23334

32	Buffalo	BUF110	0.000	0	11/4/14	36.89	0.28	96114
33	Buffalo	BUF12	0.000	0	7/6/13	36.91	0.34	10545
34	Buffalo	BUF13	0.000	0	7/8/13	36.92	0.35	11141
35	Buffalo	BUF14	0.000	0	7/8/13	36.92	0.35	25756
36	Buffalo	BUF15	0.000	0	7/8/13	36.93	0.37	7840
37	Buffalo	BUF16	0.000	0	7/8/13	36.91	0.42	12979
38	Buffalo	BUF17	0.000	0	7/8/13	36.91	0.42	15586
39	Buffalo	BUF19	0.000	0	7/10/13	36.91	0.41	18209
40	Buffalo	BUF20	0.000	0	7/10/13	36.91	0.41	21425
41	Buffalo	BUF201	0.000	0	3/3/15	36.86	0.31	11565
42	Buffalo	BUF202	0.000	0	3/3/15	36.87	0.31	17729
43	Buffalo	BUF203	0.000	0	3/8/15	36.86	0.30	25041
44	Buffalo	BUF205	0.000	0	3/8/15	36.86	0.30	16000
45	Buffalo	BUF206	0.000	0	3/8/15	36.86	0.30	10541
46	Buffalo	BUF208	0.000	0	3/10/15	36.86	0.29	17358
47	Buffalo	BUF210	0.000	0	3/13/15	36.89	0.28	22510
48	Buffalo	BUF212	0.000	0	3/13/15	36.89	0.28	33056
49	Buffalo	BUF213	0.000	0	3/13/15	36.89	0.28	47028
50	Buffalo	BUF214_PC	0.000	0	3/13/15	36.89	0.28	67214
51	Buffalo	BUF214_TK	0.000	0	3/13/15	36.86	0.30	50760
52	Buffalo	BUF215_A	0.000	0	3/13/15	36.87	0.30	53079
53	Buffalo	BUF215_B	0.000	0	3/13/15			53940
54	Buffalo	BUF216	0.000	0	3/16/15	36.87	0.30	61266
55	Buffalo	BUF217	0.000	0	3/16/15	36.88	0.30	54469
56	Buffalo	BUF218	0.000	0	3/18/15	36.91	0.28	68196
57	Buffalo	BUF219	0.000	0	3/18/15	36.91	0.28	66042
58	Buffalo	BUF220	0.000	0	3/18/15	36.91	0.28	7229
59	Buffalo	BUF222	0.000	0	3/18/15	36.91	0.28	10501
60	Buffalo	BUF223	0.000	0	3/18/15	36.87	0.29	20715
61	Buffalo	BUF23	0.000	0	7/11/13	36.92	0.35	28805
62	Buffalo	BUF24	0.000	0	7/11/13	36.92	0.36	16233
63	Buffalo	BUF25	0.000	0	7/11/13	36.83	0.51	12531
64	Buffalo	BUF26	0.000	0	7/11/13	36.82	0.49	21713
65	Buffalo	BUF27	0.000	0	7/12/13	36.91	0.30	22804
66	Buffalo	BUF28	0.000	0	7/12/13	36.91	0.31	24554
67	Buffalo	BUF29	0.000	0	7/12/13	36.92	0.35	35958
68	Buffalo	BUF30	0.000	0	7/12/13	36.92	0.35	21195
69	Buffalo	BUF31	0.000	0	7/12/13	36.87	0.30	28422
70	Buffalo	BUF32	0.000	0	7/12/13	36.87	0.31	27843

71	Buffalo	BUF33	0.000	0	7/12/13	36.89	0.29	27551
72	Buffalo	BUF34	0.000	0	7/12/13	36.89	0.29	24763
73	Buffalo	BUF35	0.000	0	7/12/13	36.88	0.30	49414
74	Buffalo	BUF36	0.000	0	7/12/13	36.88	0.30	26430
75	Buffalo	BUF37	0.000	0	7/12/13	36.89	0.28	18671
76	Buffalo	BUF38	0.000	0	7/14/13	36.91	0.34	15076
77	Buffalo	BUF39	0.000	0	7/15/13	36.91	0.40	20954
78	Buffalo	BUF40	0.000	0	7/16/13			11653
79	Buffalo	BUF41	0.000	0	7/16/13			25038
80	Buffalo	LM0028	0.000	0	7/16/16	36.91	0.28	147632
81	Buffalo	LM0077	0.000	0	7/18/16			190824
82	Buffalo	LM0083	0.000	0	7/19/16	37.02	0.28	193642
83	Buffalo	LM0088	0.000	0	7/19/16	37.03	0.30	258075
84	Buffalo	LM0115	0.000	0	7/19/16			7496
85	Buffalo	LM0162	0.000	0	7/22/16	36.89	0.31	78503
86	Buffalo	LM0163	0.000	0	7/22/16	36.89	0.31	23547
87	Buffalo	LM0164	0.000	0	7/22/16	36.89	0.31	2708
88	Buffalo	LM0243	0.000	0	7/28/16	36.89	0.28	47269
89	Buffalo	LM0294	0.000	0	7/10/16	36.88	0.31	12200
90	Buffalo	WAT206	0.000	0	3/12/15	36.91	0.29	2661
91	Buffalo	WAT207	0.000	0	3/12/15	36.91	0.29	8218
92	Buffalo	WAT208	0.000	0	3/12/15	36.91	0.28	83255
93	Bushbuck	BUS205	0.004	1	3/5/15	36.91	0.32	10880
94	Bushbuck	BUS203	0.003	1	3/5/15	36.91	0.32	28972
95	Bushbuck	BUS206	0.003	1	3/5/15	36.91	0.32	4950
96	Bushbuck	BUS211	0.003	1	3/14/15	36.91	0.32	56607
97	Bushbuck	BUS202	0.002	1	3/5/15	36.91	0.32	3622
98	Bushbuck	BUS204	0.002	1	3/5/15	36.91	0.32	25737
99	Bushbuck	BUS207	0.002	1	3/7/15	36.91	0.28	2401
100	Bushbuck	BUS208	0.002	1	3/12/15	36.91	0.32	2138
101	Bushbuck	BUS209	0.002	1	3/12/15	36.91	0.32	39622
102	Bushbuck	BUS210	0.002	1	3/14/15	36.91	0.32	81126
103	Bushbuck	BUS201	0.001	1	3/5/15	36.91	0.32	21836
104	Bushbuck	LM0044	0.000	0	7/16/16	36.91	0.32	12101
105	Camel	CAM219	0.003	1	3/8/15	36.89	0.31	66029
106	Camel	CAM216	0.002	1	3/8/15	36.89	0.31	98046
107	Camel	CAM218	0.002	1	3/8/15	36.89	0.31	77558
108	Camel	CAM102	0.001	1	11/1/14	36.92	0.37	69759
109	Camel	CAM203	0.001	1	3/5/15	36.89	0.31	66613

110	Camel	CAM205	0.001	1	3/5/15	36.89	0.31	76791
111	Camel	CAM206	0.001	1	3/5/15	36.89	0.31	81364
112	Camel	CAM210	0.001	1	3/5/15	36.89	0.31	66523
113	Camel	CAM211	0.001	1	3/5/15	36.89	0.31	7861
114	Camel	CAM212	0.001	1	3/5/15	36.89	0.31	11180
115	Camel	CAM215	0.001	1	3/8/15	36.89	0.31	56941
116	Camel	CAM217	0.001	1	3/8/15	36.89	0.31	59030
117	Camel	CAM101	0.000	0	11/1/14	36.92	0.37	81693
118	Camel	CAM103	0.000	0	11/1/14	36.92	0.37	69534
119	Camel	CAM104	0.000	0	11/1/14	36.92	0.37	68053
120	Camel	CAM105	0.000	0	11/1/14	36.92	0.37	94787
121	Camel	CAM106	0.000	0	11/1/14	36.92	0.37	69247
122	Camel	CAM107	0.000	0	11/1/14	36.92	0.37	70137
123	Camel	CAM108	0.000	0	11/1/14	36.92	0.37	63481
124	Camel	CAM109	0.000	0	11/1/14	36.92	0.37	115286
125	Camel	CAM110	0.000	0	11/1/14	36.92	0.37	98547
126	Camel	CAM111	0.000	0	11/1/14	36.92	0.37	112487
127	Camel	CAM112	0.000	0	11/1/14	36.92	0.37	109875
128	Camel	CAM201	0.000	0	3/5/15	36.89	0.31	72376
129	Camel	CAM202	0.000	0	3/5/15	36.89	0.31	61271
130	Camel	CAM204	0.000	0	3/5/15	36.89	0.31	71575
131	Camel	CAM207	0.000	0	3/5/15	36.89	0.31	94184
132	Camel	CAM208	0.000	0	3/5/15	36.89	0.31	106266
133	Camel	CAM209	0.000	0	3/5/15	36.89	0.31	100729
134	Camel	CAM213	0.000	0	3/5/15	36.89	0.31	12321
135	Camel	CAM214	0.000	0	3/5/15	36.89	0.31	8332
136	Camel	CAM220	0.000	0	3/8/15	36.89	0.31	120540
137	Camel	LM0195	0.000	0	7/24/16	36.91	0.37	60678
138	Camel	LM0196	0.000	0	7/24/16	36.91	0.37	33809
139	Camel	LM0197	0.000	0	7/24/16	36.91	0.37	51926
140	Camel	LM0198	0.000	0	7/24/16	36.91	0.37	143769
141	Camel	LM0199	0.000	0	7/24/16	36.91	0.37	9549
142	Camel	LM0201	0.000	0	7/24/16	36.91	0.37	239607
143	Camel	WAT201	0.000	0	3/5/15	36.90	0.30	6186
144	Cattle	COW250	0.005	1	3/11/15	36.87	0.33	4849
145	Cattle	COW227	0.004	1	3/7/15	36.90	0.35	17691
146	Cattle	COW251	0.004	1	3/11/15	36.87	0.33	5298
147	Cattle	COW256	0.004	1	3/11/15	36.87	0.33	10091
148	Cattle	COW229	0.003	1	3/7/15	36.90	0.35	17463

149	Cattle	COW205	0.002	1	3/7/15	36.90	0.38	172622
150	Cattle	COW209	0.002	1	3/7/15	36.88	0.38	125891
151	Cattle	COW211	0.002	1	3/7/15	36.88	0.38	153238
152	Cattle	COW212	0.002	1	3/7/15	36.88	0.38	106837
153	Cattle	COW214	0.002	1	3/7/15	36.88	0.38	40462
154	Cattle	COW215	0.002	1	3/7/15	36.88	0.38	59030
155	Cattle	COW216	0.002	1	3/7/15	36.88	0.38	81572
156	Cattle	COW217	0.002	1	3/7/15	36.88	0.38	151429
157	Cattle	COW238	0.002	1	3/7/15	36.90	0.31	84112
158	Cattle	COW239	0.002	1	3/7/15	36.90	0.31	66536
159	Cattle	COW255	0.002	1	3/11/15	36.87	0.33	7194
160	Cattle	COW29	0.002	1	7/4/13	36.90	0.44	8845
161	Cattle	COW101	0.001	1	10/31/14	36.87	0.33	56407
162	Cattle	COW103	0.001	1	10/31/14	36.87	0.33	31634
163	Cattle	COW104	0.001	1	10/31/14	36.87	0.33	72921
164	Cattle	COW120	0.001	1	11/1/14	36.88	0.38	49026
165	Cattle	COW207	0.001	1	3/7/15	36.90	0.38	120264
166	Cattle	COW208	0.001	1	3/7/15	36.90	0.38	159841
167	Cattle	COW210	0.001	1	3/7/15	36.88	0.38	97421
168	Cattle	COW213	0.001	1	3/7/15	36.88	0.38	92688
169	Cattle	COW219	0.001	1	3/7/15	36.86	0.37	85202
170	Cattle	COW231	0.001	1	3/7/15	36.90	0.35	92474
171	Cattle	COW236	0.001	1	3/7/15	36.90	0.31	81775
172	Cattle	COW244	0.001	1	3/7/15	36.88	0.31	69246
173	Cattle	COW253	0.001	1	3/11/15	36.87	0.33	12153
174	Cattle	COW254	0.001	1	3/11/15	36.87	0.33	19158
175	Cattle	COW31	0.001	1	7/5/13	36.85	0.43	11710
176	Cattle	BUF21	0.000	0	7/10/13	36.88	0.33	22286
177	Cattle	BUF22	0.000	0	7/10/13	36.88	0.33	17217
178	Cattle	COW01	0.000	0	7/2/13	36.91	0.37	9814
179	Cattle	COW02	0.000	0	7/2/13	36.91	0.37	9740
180	Cattle	COW03	0.000	0	7/2/13	36.91	0.37	14586
181	Cattle	COW04	0.000	0	7/2/13	36.91	0.37	7201
182	Cattle	COW05	0.000	0	7/2/13	36.91	0.37	8462
183	Cattle	COW06	0.000	0	7/2/13	36.91	0.37	5756
184	Cattle	COW07	0.000	0	7/2/13	36.91	0.37	6086
185	Cattle	COW08	0.000	0	7/2/13	36.91	0.37	7004
186	Cattle	COW09	0.000	0	7/2/13	36.91	0.37	7266
187	Cattle	COW10	0.000	0	7/2/13	36.91	0.37	12204

188	Cattle	COW102	0.000	0	10/31/14	36.87	0.33	63746
189	Cattle	COW105	0.000	0	10/31/14	36.87	0.33	89986
190	Cattle	COW106	0.000	0	11/1/14	36.91	0.36	43687
191	Cattle	COW107	0.000	0	11/1/14	36.91	0.36	96485
192	Cattle	COW108	0.000	0	11/1/14	36.91	0.36	14627
193	Cattle	COW109	0.000	0	11/1/14	36.91	0.36	105715
194	Cattle	COW11	0.000	0	7/2/13	36.91	0.37	12246
195	Cattle	COW111	0.000	0	11/1/14	36.91	0.36	115268
196	Cattle	COW112	0.000	0	11/1/14	36.91	0.36	57977
197	Cattle	COW113	0.000	0	11/1/14	36.91	0.36	49687
198	Cattle	COW114	0.000	0	11/1/14	36.91	0.36	74310
199	Cattle	COW115	0.000	0	11/1/14	36.91	0.36	36749
200	Cattle	COW116	0.000	0	11/1/14	36.91	0.36	68968
201	Cattle	COW117	0.000	0	11/1/14	36.87	0.33	47494
202	Cattle	COW118	0.000	0	11/1/14	36.88	0.38	59991
203	Cattle	COW119	0.000	0	11/1/14	36.88	0.38	53587
204	Cattle	COW12	0.000	0	7/2/13	36.91	0.37	8403
205	Cattle	COW121	0.000	0	11/1/14	36.88	0.38	60176
206	Cattle	COW122	0.000	0	11/1/14	36.88	0.38	37387
207	Cattle	COW123	0.000	0	11/1/14	36.88	0.38	47407
208	Cattle	COW124	0.000	0	11/1/14	36.88	0.38	56019
209	Cattle	COW125	0.000	0	11/1/14	36.88	0.38	61114
210	Cattle	COW126_R	0.000	0	11/1/14	36.88	0.38	31164
211	Cattle	COW127_R	0.000	0	11/1/14	36.90	0.38	31768
212	Cattle	COW128_R	0.000	0	11/1/14	36.90	0.38	36961
213	Cattle	COW129_R	0.000	0	11/1/14	36.90	0.38	23496
214	Cattle	COW13	0.000	0	7/2/13	36.91	0.37	10010
215	Cattle	COW130_R	0.000	0	11/1/14	36.90	0.38	28137
216	Cattle	COW131_R	0.000	0	11/1/14	36.90	0.38	33257
217	Cattle	COW132_R	0.000	0	11/1/14	36.90	0.38	35976
218	Cattle	COW133_R	0.000	0	11/1/14	36.90	0.38	26661
219	Cattle	COW134_R	0.000	0	11/1/14	36.90	0.38	43682
220	Cattle	COW14	0.000	0	7/2/13	36.91	0.37	15299
221	Cattle	COW15	0.000	0	7/4/13	36.90	0.44	11841
222	Cattle	COW16	0.000	0	7/4/13	36.90	0.44	10423
223	Cattle	COW17	0.000	0	7/4/13	36.90	0.44	9667
224	Cattle	COW18	0.000	0	7/4/13	36.90	0.44	11939
225	Cattle	COW19	0.000	0	7/4/13	36.90	0.44	9615
226	Cattle	COW20	0.000	0	7/4/13	36.90	0.44	9951

227	Cattle	COW201	0.000	0	3/7/15	36.90	0.38	91051
228	Cattle	COW202	0.000	0	3/7/15	36.90	0.38	139375
229	Cattle	COW203	0.000	0	3/7/15	36.90	0.38	113202
230	Cattle	COW204	0.000	0	3/7/15	36.90	0.38	103923
231	Cattle	COW206	0.000	0	3/7/15	36.90	0.38	102121
232	Cattle	COW21	0.000	0	7/4/13	36.90	0.44	18783
233	Cattle	COW218	0.000	0	3/7/15	36.86	0.37	119040
234	Cattle	COW22	0.000	0	7/4/13	36.90	0.44	14751
235	Cattle	COW220	0.000	0	3/7/15	36.86	0.37	63887
236	Cattle	COW228	0.000	0	3/7/15	36.90	0.35	23062
237	Cattle	COW23	0.000	0	7/4/13	36.90	0.44	11023
238	Cattle	COW230	0.000	0	3/7/15	36.90	0.35	86892
239	Cattle	COW232	0.000	0	3/7/15	36.90	0.35	91263
240	Cattle	COW233	0.000	0	3/7/15	36.90	0.35	62723
241	Cattle	COW234	0.000	0	3/7/15	36.90	0.31	79219
242	Cattle	COW235	0.000	0	3/7/15	36.90	0.31	27241
243	Cattle	COW237	0.000	0	3/7/15	36.90	0.31	84880
244	Cattle	COW24	0.000	0	7/4/13	36.90	0.44	14939
245	Cattle	COW240	0.000	0	3/7/15	36.90	0.31	133657
246	Cattle	COW241	0.000	0	3/7/15	36.90	0.31	67342
247	Cattle	COW242	0.000	0	3/7/15	36.88	0.31	83258
248	Cattle	COW243	0.000	0	3/7/15	36.88	0.31	71803
249	Cattle	COW245	0.000	0	3/7/15	36.88	0.31	77803
250	Cattle	COW246	0.000	0	3/7/15	36.88	0.31	77237
251	Cattle	COW247	0.000	0	3/7/15	36.88	0.31	79645
252	Cattle	COW248	0.000	0	3/7/15	36.88	0.31	103568
253	Cattle	COW249	0.000	0	3/7/15	36.88	0.31	96767
254	Cattle	COW25	0.000	0	7/4/13	36.90	0.44	11037
255	Cattle	COW252	0.000	0	3/11/15	36.87	0.33	6016
256	Cattle	COW257	0.000	0	3/11/15	36.87	0.33	2951
257	Cattle	COW26	0.000	0	7/4/13	36.90	0.44	11498
258	Cattle	COW27	0.000	0	7/4/13	36.90	0.44	8138
259	Cattle	COW28	0.000	0	7/4/13	36.90	0.44	10128
260	Cattle	COW30	0.000	0	7/5/13	36.85	0.43	10508
261	Cattle	COW32	0.000	0	7/5/13	36.85	0.43	8767
262	Cattle	COW33	0.000	0	7/5/13	36.85	0.43	11919
263	Cattle	COW34	0.000	0	7/5/13	36.85	0.43	10301
264	Cattle	COW35	0.000	0	7/5/13	36.85	0.43	12863
265	Cattle	COW36	0.000	0	7/5/13	36.85	0.43	9099

266	Cattle	COW37	0.000	0	7/5/13	36.85	0.43	7872
267	Cattle	COW38	0.000	0	7/5/13	36.85	0.43	11761
268	Cattle	COW39	0.000	0	7/5/13	36.85	0.43	8678
269	Cattle	COW40	0.000	0	7/5/13	36.85	0.43	13399
270	Cattle	COW41	0.000	0	7/5/13	36.85	0.43	19336
271	Cattle	COW42	0.000	0	7/5/13	36.85	0.43	28395
272	Cattle	COW43	0.000	0	7/5/13	36.85	0.43	13767
273	Cattle	COW44	0.000	0	7/5/13	36.85	0.43	13675
274	Cattle	COW45	0.000	0	7/10/13	36.88	0.50	7416
275	Cattle	COW46	0.000	0	7/10/13	36.88	0.50	20786
276	Cattle	COW47	0.000	0	7/10/13	36.88	0.50	21658
277	Cattle	COW48	0.000	0	7/10/13	36.88	0.50	8557
278	Cattle	COW49	0.000	0	7/10/13	36.88	0.50	8415
279	Cattle	COW50	0.000	0	7/10/13	36.88	0.50	17570
280	Cattle	LM0066	0.000	0	7/18/16	37.06	0.26	86074
281	Cattle	LM0107	0.000	0	7/19/16	36.96	0.29	4551
282	Cattle	LM0108	0.000	0	7/19/16	36.96	0.29	72156
283	Cattle	LM0109	0.000	0	7/19/16	36.96	0.29	43971
284	Cattle	LM0110	0.000	0	7/19/16	36.96	0.29	77921
285	Cattle	LM0111	0.000	0	7/19/16	36.96	0.29	8590
286	Cattle	LM0112	0.000	0	7/19/16	36.96	0.29	26110
287	Cattle	LM0113	0.000	0	7/19/16	36.96	0.29	20211
288	Cattle	LM0114	0.000	0	7/19/16	36.96	0.29	118925
289	Cattle	LM0273	0.000	0	7/29/16	36.87	0.40	42287
290	Cattle	LM0274	0.000	0	7/29/16	36.87	0.40	45140
291	Cattle	LM0275	0.000	0	7/29/16	36.87	0.40	65786
292	Cattle	LM0276	0.000	0	7/29/16	36.87	0.40	80276
293	Cattle	LM0277	0.000	0	7/29/16	36.87	0.40	104170
294	Cattle	LM0278	0.000	0	7/29/16	36.87	0.40	53990
295	Cattle	LM0279	0.000	0	7/29/16	36.87	0.40	74433
296	Cattle	LM0280	0.000	0	7/29/16	36.87	0.40	66763
297	Cattle	LM0281	0.000	0	7/29/16	36.87	0.40	86735
298	Cattle	LM0282	0.000	0	7/29/16	36.87	0.34	255893
299	Cattle	LM0283	0.000	0	7/29/16	36.87	0.34	123351
300	Cattle	LM0284	0.000	0	7/29/16	36.87	0.34	186171
301	Cattle	LM0285	0.000	0	7/29/16	36.87	0.34	131744
302	Cattle	LM0286	0.000	0	7/29/16	36.87	0.34	41423
303	Cattle	LM0287	0.000	0	7/29/16	36.87	0.34	90497
304	Cattle	LM0288	0.000	0	7/29/16	36.87	0.34	59815

305	Cattle	LM0289	0.000	0	7/29/16	36.87	0.34	59079
306	Cattle	LM0290	0.000	0	7/29/16	36.87	0.34	131064
307	Dik-Dik	DIK258	0.052	1	3/10/15	36.89	0.28	103109
308	Dik-Dik	DIK206	0.044	1	3/9/15	36.89	0.28	166158
309	Dik-Dik	DIK254	0.032	1	3/10/15	36.91	0.40	118908
310	Dik-Dik	DIK205	0.029	1	3/9/15	36.89	0.28	152237
311	Dik-Dik	DIK220_R	0.026	1	3/9/15	36.91	0.40	23687
312	Dik-Dik	DIK217_R	0.024	1	3/9/15	36.91	0.40	165529
313	Dik-Dik	DIK219_R	0.024	1	3/9/15	36.91	0.40	17888
314	Dik-Dik	DIK204	0.020	1	3/9/15	36.89	0.28	142103
315	Dik-Dik	DIK246	0.014	1	3/10/15	36.91	0.40	93985
316	Dik-Dik	DIK233	0.013	1	3/10/15	36.91	0.40	82033
317	Dik-Dik	DIK226	0.011	1	3/10/15	36.89	0.28	113512
318	Dik-Dik	DIK229	0.009	1	3/10/15	36.89	0.29	91317
319	Dik-Dik	DIK235	0.009	1	3/10/15	36.90	0.28	50931
320	Dik-Dik	DIK256	0.009	1	3/10/15	36.89	0.29	74530
321	Dik-Dik	DIK234	0.006	1	3/10/15	36.90	0.28	34049
322	Dik-Dik	DIK208	0.005	1	3/9/15	36.91	0.40	148974
323	Dik-Dik	DIK250	0.005	1	3/10/15	36.89	0.29	55045
324	Dik-Dik	DIK255	0.005	1	3/10/15	36.91	0.40	112926
325	Dik-Dik	DIK203	0.004	1	3/8/15	36.87	0.37	227339
326	Dik-Dik	DIK216_R	0.004	1	3/9/15	36.91	0.40	102678
327	Dik-Dik	DIK251	0.004	1	3/10/15	36.89	0.29	71864
328	Dik-Dik	DIK123	0.003	1	11/3/14	36.91	0.40	35759
329	Dik-Dik	DIK133	0.003	1	11/3/14	36.91	0.40	53981
330	Dik-Dik	DIK201	0.003	1	3/4/15	36.92	0.37	86993
331	Dik-Dik	DIK207	0.003	1	3/9/15	36.91	0.40	179473
332	Dik-Dik	DIK218_R	0.003	1	3/9/15	36.91	0.40	100256
333	Dik-Dik	DIK247	0.003	1	3/10/15	36.91	0.40	32501
334	Dik-Dik	DIK263	0.003	1	3/14/15	36.91	0.33	46888
335	Dik-Dik	DIK109	0.002	1	10/31/14	36.89	0.28	129525
336	Dik-Dik	DIK114	0.002	1	11/3/14	36.91	0.40	117594
337	Dik-Dik	DIK116	0.002	1	11/3/14	36.91	0.40	66257
338	Dik-Dik	DIK137	0.002	1	11/3/14	36.89	0.29	75765
339	Dik-Dik	DIK20	0.002	1	6/26/13	36.87	0.42	17473
340	Dik-Dik	DIK202	0.002	1	3/8/15	36.87	0.38	192372
341	Dik-Dik	DIK259	0.002	1	3/14/15	36.91	0.32	180115
342	Dik-Dik	DIK260	0.002	1	3/14/15	36.91	0.32	54677
343	Dik-Dik	DIK262	0.002	1	3/14/15	36.91	0.33	26670

344	Dik-Dik	DIK37	0.002	1	7/11/13	36.86	0.46	9811
345	Dik-Dik	DIK43	0.002	1	7/12/13	36.90	0.30	12521
346	Dik-Dik	LM0232	0.002	1	7/27/16	36.91	0.32	17643
347	Dik-Dik	LM0247	0.002	1	7/28/16	36.89	0.28	134304
348	Dik-Dik	DIK107	0.001	1	10/31/14	36.89	0.28	42220
349	Dik-Dik	DIK111	0.001	1	11/1/14	36.91	0.33	149141
350	Dik-Dik	DIK115	0.001	1	11/3/14	36.91	0.40	127078
351	Dik-Dik	DIK124	0.001	1	11/3/14	36.91	0.40	48369
352	Dik-Dik	DIK132	0.001	1	11/3/14	36.91	0.40	56162
353	Dik-Dik	DIK138	0.001	1	11/3/14	36.89	0.29	127517
354	Dik-Dik	DIK139	0.001	1	11/3/14	36.89	0.29	77087
355	Dik-Dik	DIK143_R	0.001	1	11/4/14	36.90	0.28	38701
356	Dik-Dik	DIK147	0.001	1	11/4/14	36.89	0.29	75596
357	Dik-Dik	DIK22	0.001	1	6/27/13	36.93	0.37	41740
358	Dik-Dik	DIK225_R	0.001	1	3/10/15	36.91	0.40	18886
359	Dik-Dik	DIK24	0.001	1	6/27/13	36.91	0.40	35132
360	Dik-Dik	DIK248	0.001	1	3/10/15	36.91	0.40	51769
361	Dik-Dik	DIK31	0.001	1	7/10/13	36.91	0.41	28683
362	Dik-Dik	DIK35	0.001	1	7/10/13	36.87	0.48	11528
363	Dik-Dik	DIK46	0.001	1	7/15/13	36.91	0.40	20499
364	Dik-Dik	LM0216	0.001	1	7/25/16	36.88	0.40	44001
365	Dik-Dik	LM0246	0.001	1	7/28/16	36.89	0.28	55403
366	Dik-Dik	LM0270	0.001	1	7/29/16	36.88	0.29	14450
367	Dik-Dik	DIK01	0.000	0	6/24/13	36.91	0.34	15790
368	Dik-Dik	DIK02	0.000	0	6/24/13	36.91	0.34	20321
369	Dik-Dik	DIK03	0.000	0	6/24/13	36.91	0.34	11352
370	Dik-Dik	DIK04	0.000	0	6/24/13	36.89	0.28	28411
371	Dik-Dik	DIK06	0.000	0	6/25/13	36.89	0.29	7645
372	Dik-Dik	DIK07	0.000	0	6/25/13	36.87	0.36	13590
373	Dik-Dik	DIK08	0.000	0	6/25/13	36.92	0.40	17206
374	Dik-Dik	DIK09	0.000	0	6/25/13	36.90	0.37	6959
375	Dik-Dik	DIK10	0.000	0	6/25/13	36.89	0.29	12720
376	Dik-Dik	DIK101	0.000	0	10/28/14	36.91	0.40	56689
377	Dik-Dik	DIK102	0.000	0	10/30/14	36.89	0.30	38817
378	Dik-Dik	DIK103	0.000	0	10/30/14	36.89	0.30	54555
379	Dik-Dik	DIK104	0.000	0	10/31/14	36.89	0.28	51561
380	Dik-Dik	DIK105	0.000	0	10/31/14	36.89	0.28	44576
381	Dik-Dik	DIK106	0.000	0	10/31/14	36.89	0.28	95204
382	Dik-Dik	DIK108	0.000	0	10/31/14	36.89	0.28	123386

383	Dik-Dik	DIK11	0.000	0	6/25/13	36.88	0.30	12057
384	Dik-Dik	DIK110	0.000	0	11/1/14	36.91	0.32	101214
385	Dik-Dik	DIK112	0.000	0	11/1/14	36.91	0.33	107282
386	Dik-Dik	DIK113	0.000	0	11/2/14	36.91	0.31	96852
387	Dik-Dik	DIK12	0.000	0	6/25/13	36.88	0.30	24420
388	Dik-Dik	DIK122	0.000	0	11/3/14	36.91	0.40	38990
389	Dik-Dik	DIK13	0.000	0	6/25/13	36.88	0.30	37022
390	Dik-Dik	DIK14	0.000	0	6/26/13	36.86	0.46	10940
391	Dik-Dik	DIK141	0.000	0	11/4/14	36.90	0.28	62762
392	Dik-Dik	DIK142	0.000	0	11/4/14	36.90	0.28	58374
393	Dik-Dik	DIK15	0.000	0	6/26/13	36.87	0.45	12419
394	Dik-Dik	DIK151	0.000	0	11/4/14	36.91	0.40	43569
395	Dik-Dik	DIK152	0.000	0	11/4/14	36.91	0.40	82485
396	Dik-Dik	DIK153	0.000	0	11/4/14	36.91	0.40	56883
397	Dik-Dik	DIK154	0.000	0	11/4/14	36.91	0.40	65771
398	Dik-Dik	DIK16	0.000	0	6/26/13	36.86	0.45	14216
399	Dik-Dik	DIK17	0.000	0	6/26/13	36.86	0.45	9464
400	Dik-Dik	DIK18	0.000	0	6/26/13	36.86	0.43	26085
401	Dik-Dik	DIK19	0.000	0	6/26/13	36.87	0.43	25846
402	Dik-Dik	DIK21	0.000	0	6/27/13	36.91	0.33	16243
403	Dik-Dik	DIK23	0.000	0	6/27/13	36.91	0.40	8275
404	Dik-Dik	DIK25	0.000	0	6/27/13	36.90	0.41	22682
405	Dik-Dik	DIK26	0.000	0	6/27/13	36.87	0.38	21426
406	Dik-Dik	DIK27	0.000	0	6/27/13	36.87	0.38	2485
407	Dik-Dik	DIK28	0.000	0	6/28/13	36.92	0.36	24680
408	Dik-Dik	DIK29	0.000	0	7/10/13	36.91	0.41	6854
409	Dik-Dik	DIK30	0.000	0	7/10/13	36.91	0.41	14501
410	Dik-Dik	DIK32	0.000	0	7/10/13	36.86	0.47	50414
411	Dik-Dik	DIK33	0.000	0	7/10/13	36.86	0.47	15277
412	Dik-Dik	DIK34	0.000	0	7/10/13	36.86	0.48	14259
413	Dik-Dik	DIK36	0.000	0	7/11/13	36.86	0.44	7024
414	Dik-Dik	DIK38	0.000	0	7/11/13	36.86	0.46	18089
415	Dik-Dik	DIK39	0.000	0	7/11/13	36.86	0.46	6450
416	Dik-Dik	DIK40	0.000	0	7/11/13	36.86	0.46	7760
417	Dik-Dik	DIK41	0.000	0	7/11/13	36.86	0.48	19089
418	Dik-Dik	DIK42	0.000	0	7/11/13	36.86	0.49	12738
419	Dik-Dik	DIK44	0.000	0	7/14/13	36.91	0.40	24334
420	Dik-Dik	DIK45	0.000	0	7/15/13	36.91	0.40	7666
421	Dik-Dik	DIK47	0.000	0	7/15/13	36.91	0.40	12220

422	Dik-Dik	LM0010	0.000	0	7/15/16	36.89	0.29	179948
423	Dik-Dik	LM0011	0.000	0	7/15/16	36.89	0.29	149921
424	Dik-Dik	LM0233	0.000	0	7/27/16	36.91	0.32	244604
425	Dik-Dik	LM0248	0.000	0	7/28/16	36.89	0.28	20902
426	Dik-Dik	LM0269	0.000	0	7/29/16	36.88	0.29	39300
427	Donkey	DON202	0.002	1	3/11/15	36.87	0.33	13605
428	Donkey	DON201	0.001	1	3/11/15	36.87	0.33	15760
429	Donkey	DON203	0.001	1	3/12/15	36.87	0.33	11711
430	Donkey	DON101	0.000	0	10/31/14	36.88	0.33	44244
431	Donkey	DON102	0.000	0	10/31/14	36.88	0.33	31670
432	Donkey	DON103	0.000	0	10/31/14	36.88	0.33	45931
433	Donkey	DON104	0.000	0	10/31/14	36.88	0.33	29218
434	Donkey	DON105	0.000	0	10/31/14	36.88	0.33	64350
435	Donkey	DON106	0.000	0	10/31/14	36.88	0.33	39596
436	Donkey	DON107	0.000	0	10/31/14	36.88	0.33	70736
437	Donkey	DON108	0.000	0	10/31/14	36.88	0.33	14679
438	Donkey	DON109	0.000	0	10/31/14	36.88	0.33	20918
439	Donkey	DON204	0.000	0	3/12/15	36.87	0.33	13885
440	Donkey	DON205	0.000	0	3/12/15	36.87	0.33	9117
441	Donkey	DON206	0.000	0	3/12/15	36.87	0.33	12170
442	Donkey	DON207	0.000	0	3/12/15	36.87	0.33	15020
443	Donkey	DON208	0.000	0	3/12/15	36.87	0.33	16230
444	Donkey	DON209	0.000	0	3/12/15	36.87	0.33	9584
445	Donkey	DON210	0.000	0	3/12/15	36.87	0.33	15652
446	Donkey	LM0249	0.000	0	7/28/16	36.88	0.36	212929
447	Donkey	LM0250	0.000	0	7/28/16	36.88	0.36	29444
448	Donkey	LM0251	0.000	0	7/28/16	36.88	0.36	48046
449	Donkey	LM0252	0.000	0	7/28/16	36.88	0.36	107692
450	Donkey	LM0253	0.000	0	7/28/16	36.88	0.36	6490
451	Donkey	LM0254	0.000	0	7/28/16	36.88	0.36	119603
452	Donkey	LM0255	0.000	0	7/28/16	36.88	0.36	20718
453	Donkey	LM0256	0.000	0	7/28/16	36.88	0.36	77799
454	Donkey	LM0257	0.000	0	7/28/16	36.88	0.36	228162
455	Donkey	LM0258	0.000	0	7/28/16	36.88	0.36	95700
456	Eland	ELA201	0.007	1	3/3/15	36.88	0.29	17397
457	Eland	ELA202	0.005	1	3/3/15	36.88	0.29	9259
458	Eland	LM0134	0.002	1	7/20/16	36.91	0.31	30130
459	Eland	LM0204	0.002	1	7/25/16	36.88	0.39	143084
460	Eland	WHO104	0.002	1	10/30/14	36.89	0.30	38252

461	Eland	ELA107	0.001	1	10/30/14	36.87	0.28	29425
462	Eland	ELA114	0.001	1	10/30/14	36.87	0.28	37216
463	Eland	ELA115	0.001	1	11/2/14	36.89	0.28	28804
464	Eland	ELA116	0.001	1	11/2/14	36.89	0.29	42562
465	Eland	LM0179	0.001	1	7/23/16	36.91	0.31	11311
466	Eland	ELA101	0.000	0	10/29/14	36.87	0.30	42430
467	Eland	ELA102	0.000	0	10/30/14	36.87	0.28	61938
468	Eland	ELA103	0.000	0	10/30/14	36.87	0.28	103176
469	Eland	ELA104	0.000	0	10/30/14	36.87	0.28	62130
470	Eland	ELA105	0.000	0	10/30/14	36.87	0.28	75452
471	Eland	ELA106	0.000	0	10/30/14	36.87	0.28	59444
472	Eland	ELA108	0.000	0	10/30/14	36.87	0.28	18628
473	Eland	ELA109	0.000	0	10/30/14	36.87	0.28	38399
474	Eland	ELA110	0.000	0	10/30/14	36.87	0.28	38686
475	Eland	ELA111	0.000	0	10/30/14	36.87	0.28	40863
476	Eland	ELA112	0.000	0	10/30/14	36.87	0.28	38643
477	Eland	ELA113	0.000	0	10/30/14	36.87	0.28	74469
478	Eland	ELA117	0.000	0	11/2/14	36.87	0.30	40020
479	Eland	ELA118	0.000	0	11/2/14	36.87	0.30	40972
480	Eland	ELA204	0.000	0	3/16/15	36.86	0.31	7578
481	Eland	LM0146	0.000	0	7/21/16	36.90	0.34	61263
482	Eland	LM0147	0.000	0	7/21/16	36.90	0.34	56778
483	Eland	LM0205	0.000	0	7/25/16	36.88	0.39	121376
484	Eland	LM0206	0.000	0	7/25/16	36.88	0.39	131729
485	Eland	LM0207	0.000	0	7/25/16	36.88	0.39	4730
486	Eland	LM0208	0.000	0	7/25/16	36.88	0.39	115501
487	Eland	LM0209	0.000	0	7/25/16	36.88	0.39	6599
488	Eland	LM0210	0.000	0	7/25/16	36.88	0.39	110526
489	Eland	LM0211	0.000	0	7/25/16	36.88	0.40	182910
490	Eland	LM0237	0.000	0	7/28/16	36.96	0.31	6973
491	Eland	LM0320	0.000	0	8/6/16	36.95	0.34	67700
492	Eland	LM0321	0.000	0	8/6/16	36.95	0.34	52366
493	Eland	LM0322	0.000	0	8/6/16	36.95	0.34	106519
494	Eland	LM0323	0.000	0	8/6/16	36.95	0.34	50735
495	Eland	LM0324	0.000	0	8/6/16	36.95	0.34	34544
496	Eland	LM0325	0.000	0	8/6/16	36.95	0.34	94769
497	Eland	LM0326	0.000	0	8/6/16	36.95	0.34	46716
498	Eland	LM0327	0.000	0	8/6/16	36.95	0.34	19306
499	Eland	LM0328	0.000	0	8/6/16	36.95	0.34	197644

500	Eland	LM0329	0.000	0	8/6/16	36.95	0.34	100550
501	Eland	LM0330	0.000	0	8/6/16	36.95	0.34	117364
502	Eland	LM0331	0.000	0	8/6/16	36.95	0.34	68735
503	Eland	LM0332	0.000	0	8/6/16	36.95	0.34	92503
504	Eland	LM0333	0.000	0	8/6/16	36.95	0.34	70393
505	Eland	LM0334	0.000	0	8/6/16	36.95	0.34	16934
506	Eland	LM0335	0.000	0	8/6/16	36.95	0.34	91456
507	Eland	LM0336	0.000	0	8/6/16	36.95	0.34	77660
508	Eland	LM0341	0.000	0	8/6/16	36.93	0.29	55873
509	Eland	LM0342	0.000	0	8/6/16	36.93	0.29	22587
510	Elephant	ELE211	0.037	1	3/7/15	36.92	0.38	54340
511	Elephant	ELE204	0.019	1	3/4/15	36.92	0.35	30582
512	Elephant	ELE215	0.011	1	3/10/15	36.91	0.32	15561
513	Elephant	ELE224	0.010	1	3/13/15	36.90	0.38	60864
514	Elephant	ELE101	0.006	1	10/26/14	36.89	0.36	114843
515	Elephant	ELE216	0.006	1	3/13/15	36.92	0.36	19567
516	Elephant	ELE104	0.005	1	10/29/14	36.91	0.30	118967
517	Elephant	ELE210	0.005	1	3/7/15	36.91	0.41	56115
518	Elephant	ELE225	0.005	1	3/15/15	36.88	0.39	38450
519	Elephant	ELE203	0.004	1	3/3/15	36.87	0.34	23143
520	Elephant	ELE202	0.003	1	3/3/15	36.87	0.34	20725
521	Elephant	LM0054	0.003	1	7/18/16	37.01	0.29	146973
522	Elephant	ELE106	0.002	1	10/31/14	36.89	0.29	125691
523	Elephant	ELE11	0.002	1	6/26/13	36.87	0.42	14231
524	Elephant	ELE201	0.002	1	3/1/15	36.91	0.34	22047
525	Elephant	ELE205	0.002	1	3/7/15	36.91	0.29	18188
526	Elephant	ELE212	0.002	1	3/7/15	36.92	0.38	41697
527	Elephant	ELE213	0.002	1	3/7/15	36.92	0.38	27679
528	Elephant	ELE223	0.002	1	3/11/15	36.88	0.35	126072
529	Elephant	ELE226	0.002	1	3/16/15	36.88	0.29	71034
530	Elephant	ELE227	0.002	1	3/16/15	36.86	0.28	37383
531	Elephant	ELE228	0.002	1	3/17/15	36.87	0.33	14830
532	Elephant	ELE36	0.002	1	7/12/13	36.91	0.34	36544
533	Elephant	LM0023	0.002	1	7/15/16	36.91	0.34	116684
534	Elephant	ELE102	0.001	1	10/26/14	36.88	0.35	92451
535	Elephant	ELE108	0.001	1	10/31/14	36.89	0.29	93910
536	Elephant	ELE113	0.001	1	11/4/14	36.91	0.33	161632
537	Elephant	ELE18	0.001	1	6/28/13	36.88	0.35	12866
538	Elephant	ELE20	0.001	1	6/28/13	36.91	0.33	9569

539	Elephant	ELE206	0.001	1	3/7/15	36.91	0.29	28379
540	Elephant	ELE207	0.001	1	3/7/15	36.91	0.30	22848
541	Elephant	ELE218	0.001	1	3/13/15	36.93	0.36	22221
542	Elephant	ELE22	0.001	1	6/28/13	36.91	0.33	12281
543	Elephant	ELE220	0.001	1	3/13/15	36.93	0.36	20811
544	Elephant	ELE221	0.001	1	3/13/15	36.93	0.37	103259
545	Elephant	ELE222	0.001	1	3/13/15	36.92	0.36	129358
546	Elephant	LM0030	0.001	1	7/16/16	36.91	0.29	96302
547	Elephant	ELE01	0.000	0	6/25/13	36.91	0.40	12126
548	Elephant	ELE02	0.000	0	6/25/13	36.92	0.40	18104
549	Elephant	ELE03	0.000	0	6/25/13	36.92	0.38	14879
550	Elephant	ELE04	0.000	0	6/25/13	36.92	0.38	16761
551	Elephant	ELE05	0.000	0	6/25/13	36.92	0.38	16616
552	Elephant	ELE06	0.000	0	6/25/13	36.92	0.38	21756
553	Elephant	ELE07	0.000	0	6/26/13	36.85	0.42	13249
554	Elephant	ELE08	0.000	0	6/26/13	36.85	0.43	18517
555	Elephant	ELE09	0.000	0	6/26/13	36.87	0.48	10524
556	Elephant	ELE10	0.000	0	6/26/13	36.86	0.47	7508
557	Elephant	ELE103	0.000	0	10/28/14	36.93	0.37	96585
558	Elephant	ELE105	0.000	0	10/29/14	36.91	0.32	82729
559	Elephant	ELE107	0.000	0	10/31/14	36.89	0.29	114448
560	Elephant	ELE109	0.000	0	10/31/14	36.89	0.29	114080
561	Elephant	ELE110	0.000	0	11/1/14	36.90	0.30	102621
562	Elephant	ELE111	0.000	0	11/1/14	36.91	0.30	92979
563	Elephant	ELE112	0.000	0	11/2/14	36.88	0.30	110853
564	Elephant	ELE12	0.000	0	6/26/13	36.91	0.34	11043
565	Elephant	ELE13	0.000	0	6/27/13	36.90	0.41	11952
566	Elephant	ELE14	0.000	0	6/27/13	36.87	0.38	10911
567	Elephant	ELE15	0.000	0	6/27/13	36.87	0.38	15552
568	Elephant	ELE16	0.000	0	6/27/13	36.87	0.38	16929
569	Elephant	ELE17	0.000	0	6/27/13	36.88	0.31	11763
570	Elephant	ELE19	0.000	0	6/28/13	36.92	0.36	13004
571	Elephant	ELE208	0.000	0	3/7/15	36.91	0.30	147558
572	Elephant	ELE209	0.000	0	3/7/15	36.91	0.41	111725
573	Elephant	ELE21	0.000	0	6/28/13	36.91	0.33	10136
574	Elephant	ELE214	0.000	0	3/10/15	36.91	0.32	71361
575	Elephant	ELE217	0.000	0	3/13/15	36.93	0.36	12944
576	Elephant	ELE219	0.000	0	3/13/15	36.93	0.36	30025
577	Elephant	ELE23	0.000	0	6/28/13	36.91	0.33	16145

578	Elephant	ELE24	0.000	0	6/28/13	36.91	0.33	11319
579	Elephant	ELE25	0.000	0	6/28/13	36.91	0.33	17146
580	Elephant	ELE26	0.000	0	6/29/13	36.89	0.28	12672
581	Elephant	LM0001	0.000	0	7/14/16	36.91	0.32	25601
582	Elephant	LM0002	0.000	0	7/14/16	36.91	0.33	24779
583	Elephant	LM0021	0.000	0	7/15/16	36.88	0.36	183605
584	Elephant	LM0024	0.000	0	7/15/16	36.91	0.34	316973
585	Elephant	LM0031	0.000	0	7/16/16	36.91	0.30	171553
586	Elephant	LM0032	0.000	0	7/16/16	36.91	0.30	151361
587	Elephant	LM0101	0.000	0	7/19/16	36.96	0.36	73827
588	Elephant	LM0102	0.000	0	7/19/16	36.96	0.36	32779
589	Elephant	LM0260	0.000	0	7/29/16	36.89	0.35	38889
590	Giraffe	LM0217	0.025	1	7/25/16	36.88	0.40	5960
591	Giraffe	LM0212	0.012	1	7/25/16	36.88	0.40	40225
592	Giraffe	LM0214	0.012	1	7/25/16	36.88	0.40	4698
593	Giraffe	GIR220	0.009	1	3/16/15	36.90	0.30	44742
594	Giraffe	GIR202	0.008	1	3/1/15	36.91	0.31	81360
595	Giraffe	LM0143	0.008	1	7/21/16	36.90	0.34	19885
596	Giraffe	GIR203	0.007	1	3/1/15	36.88	0.36	5426
597	Giraffe	GIR217	0.007	1	3/15/15	36.89	0.33	91940
598	Giraffe	GIR201	0.005	1	3/1/15	36.90	0.36	8733
599	Giraffe	GIR206	0.005	1	3/8/15	36.88	0.35	117650
600	Giraffe	GIR207	0.005	1	3/10/15	36.87	0.35	57337
601	Giraffe	GIR210	0.005	1	3/10/15	36.87	0.35	17353
602	Giraffe	LM0142	0.005	1	7/21/16	36.90	0.34	28905
603	Giraffe	LM0213	0.005	1	7/25/16	36.88	0.40	27728
604	Giraffe	GIR116	0.004	1	11/3/14	36.89	0.37	16807
605	Giraffe	LM0022	0.004	1	7/15/16	36.91	0.30	263261
606	Giraffe	LM0152	0.004	1	7/22/16	36.91	0.32	197949
607	Giraffe	GIR111	0.003	1	11/2/14	36.90	0.38	88151
608	Giraffe	GIR204	0.003	1	3/8/15	36.88	0.35	50758
609	Giraffe	GIR209	0.003	1	3/10/15	36.87	0.35	30308
610	Giraffe	GIR221	0.003	1	3/16/15	36.90	0.30	32475
611	Giraffe	LM0259	0.003	1	7/29/16	36.89	0.35	88170
612	Giraffe	GIR109	0.002	1	10/31/14	36.89	0.30	44276
613	Giraffe	GIR205	0.002	1	3/8/15	36.88	0.35	117886
614	Giraffe	GIR208	0.002	1	3/10/15	36.87	0.35	31231
615	Giraffe	GIR212	0.002	1	3/14/15	36.91	0.31	67864
616	Giraffe	GIR215	0.002	1	3/15/15	36.89	0.33	21354

617	Giraffe	GIR216	0.002	1	3/15/15	36.89	0.33	38360
618	Giraffe	LM0144	0.002	1	7/21/16	36.90	0.34	136088
619	Giraffe	LM0337	0.002	1	8/6/16	36.94	0.34	79713
620	Giraffe	GIR101	0.001	1	10/26/14	36.88	0.35	88368
621	Giraffe	GIR103	0.001	1	10/26/14	36.88	0.35	92953
622	Giraffe	GIR104	0.001	1	10/27/14	36.89	0.31	41040
623	Giraffe	GIR108	0.001	1	10/30/14	36.90	0.29	38076
624	Giraffe	GIR112	0.001	1	11/2/14	36.89	0.28	81947
625	Giraffe	GIR213	0.001	1	3/14/15	36.91	0.32	44666
626	Giraffe	GIR219	0.001	1	3/15/15	36.91	0.31	44047
627	Giraffe	GIR102	0.000	0	10/26/14	36.88	0.35	131325
628	Giraffe	GIR105	0.000	0	10/27/14	36.89	0.31	85352
629	Giraffe	GIR106	0.000	0	10/27/14	36.89	0.31	77760
630	Giraffe	GIR107	0.000	0	10/27/14	36.89	0.31	84216
631	Giraffe	GIR110	0.000	0	10/31/14	36.89	0.30	73114
632	Giraffe	GIR113	0.000	0	11/2/14	36.87	0.30	56635
633	Giraffe	GIR114	0.000	0	11/2/14	36.87	0.30	53411
634	Giraffe	GIR115	0.000	0	11/3/14	36.89	0.37	99997
635	Giraffe	GIR211	0.000	0	3/14/15	36.91	0.31	13352
636	Giraffe	GIR214	0.000	0	3/15/15	36.89	0.33	42069
637	Giraffe	GIR218	0.000	0	3/15/15	36.91	0.31	48590
638	Giraffe	LM0025	0.000	0	7/15/16	36.91	0.31	84152
639	Giraffe	LM0124	0.000	0	7/20/16	36.94	0.28	146058
640	Giraffe	LM0154	0.000	0	7/22/16	36.91	0.32	31428
641	Giraffe	LM0313	0.000	0	8/6/16	36.96	0.31	60587
642	Giraffe	LM0314	0.000	0	8/6/16	36.96	0.31	63091
643	Giraffe	LM0315	0.000	0	8/6/16	36.96	0.31	52561
644	Giraffe	LM0316	0.000	0	8/6/16	36.96	0.33	64904
645	Giraffe	LM0317	0.000	0	8/6/16	36.96	0.33	47843
646	Giraffe	LM0338	0.000	0	8/6/16	36.94	0.34	250866
647	Giraffe	LM0339	0.000	0	8/6/16	36.94	0.34	170799
648	Goat	LM0185	0.003	1	7/24/16	36.87	0.36	114785
649	Goat	GOA201	0.002	1	3/7/15	36.89	0.32	31479
650	Goat	GOA101	0.001	1		36.87	0.34	56340
651	Goat	GOA202	0.001	1	3/7/15	36.89	0.32	12758
652	Goat	GOA203	0.001	1	3/7/15	36.89	0.32	20536
653	Goat	LM0177	0.001	1	7/22/16	36.90	0.32	19205
654	Goat	LM0182	0.001	1	7/24/16	36.87	0.36	16344
655	Goat	LM0186	0.001	1	7/24/16	36.87	0.36	2527

656	Goat	GOA102	0.000	0		36.87	0.34	77156
657	Goat	GOA103	0.000	0		36.87	0.34	42393
658	Goat	GOA204	0.000	0	3/16/15	36.89	0.32	15489
659	Goat	GOA205	0.000	0	3/16/15	36.89	0.32	2030
660	Goat	GOA206	0.000	0	3/16/15	36.89	0.32	14851
661	Goat	LM0175	0.000	0	7/22/16	36.90	0.32	145791
662	Goat	LM0176	0.000	0	7/22/16	36.90	0.32	4874
663	Goat	LM0178	0.000	0	7/22/16	36.90	0.32	34003
664	Goat	LM0183	0.000	0	7/24/16	36.87	0.36	466343
665	Goat	LM0184	0.000	0	7/24/16	36.87	0.36	32233
666	Goat	LM0308	0.000	0	8/3/16	36.88	0.36	94289
667	Grevy's zebra	GRE202	0.004	1	3/2/15	36.90	0.37	23845
668	Grevy's zebra	GRE228	0.002	1	3/17/15	36.88	0.28	46559
669	Grevy's zebra	GRE201	0.001	1	3/1/15	36.89	0.29	24874
670	Grevy's zebra	GRE205	0.001	1	3/4/15	36.89	0.35	14880
671	Grevy's zebra	GRE207	0.001	1	3/4/15	36.91	0.32	23490
672	Grevy's zebra	GRE208	0.001	1	3/7/15	36.92	0.40	17059
673	Grevy's zebra	GRE215	0.001	1	3/13/15	36.92	0.38	9550
674	Grevy's zebra	GRE223	0.001	1	3/15/15	36.89	0.28	51030
675	Grevy's zebra	LM0048	0.001	1	7/17/16	36.90	0.30	40578
676	Grevy's zebra	LM0225	0.001	1	7/26/16	36.91	0.33	7921
677	Grevy's zebra	GRE01	0.000	0	6/24/13			3518
678	Grevy's zebra	GRE02	0.000	0	6/26/13	36.88	0.31	7069
679	Grevy's zebra	GRE03	0.000	0	6/27/13	36.88	0.31	4209
680	Grevy's zebra	GRE04	0.000	0	6/27/13	36.90	0.30	8767
681	Grevy's zebra	GRE05	0.000	0	6/27/13	36.90	0.30	6857
682	Grevy's zebra	GRE06	0.000	0	6/27/13	36.90	0.30	4232
683	Grevy's zebra	GRE07	0.000	0	6/27/13	36.90	0.30	15169
684	Grevy's zebra	GRE08	0.000	0	6/28/13	36.88	0.31	4716
685	Grevy's zebra	GRE09	0.000	0	6/28/13	36.88	0.31	6186
686	Grevy's zebra	GRE10	0.000	0	6/28/13	36.88	0.31	7943
687	Grevy's zebra	GRE101	0.000	0	10/27/14	36.89	0.36	41961
688	Grevy's zebra	GRE102	0.000	0	10/27/14	36.89	0.36	43799
689	Grevy's zebra	GRE103	0.000	0	10/28/14	36.92	0.38	46927
690	Grevy's zebra	GRE104	0.000	0	10/29/14	36.88	0.28	50849
691	Grevy's zebra	GRE105	0.000	0	11/2/14	36.89	0.35	33413
692	Grevy's zebra	GRE106	0.000	0	11/2/14	36.90	0.30	63659
693	Grevy's zebra	GRE107	0.000	0	11/3/14	36.91	0.34	37855
694	Grevy's zebra	GRE108	0.000	0	11/3/14	36.91	0.34	58081

695	Grevy's zebra	GRE109	0.000	0	11/3/14	36.91	0.34	63404
696	Grevy's zebra	GRE110	0.000	0	11/3/14	36.91	0.34	2128
697	Grevy's zebra	GRE111	0.000	0	11/3/14	36.91	0.34	27436
698	Grevy's zebra	GRE112	0.000	0	11/3/14	36.92	0.37	27888
699	Grevy's zebra	GRE113	0.000	0	11/3/14	36.92	0.37	81029
700	Grevy's zebra	GRE114	0.000	0	11/3/14	36.92	0.37	56548
701	Grevy's zebra	GRE115	0.000	0	11/3/14	36.89	0.37	51406
702	Grevy's zebra	GRE116	0.000	0	11/3/14	36.88	0.31	40000
703	Grevy's zebra	GRE15	0.000	0	7/2/13	36.92	0.38	5063
704	Grevy's zebra	GRE16	0.000	0	7/2/13	36.92	0.38	10120
705	Grevy's zebra	GRE17	0.000	0	7/2/13	36.92	0.38	9045
706	Grevy's zebra	GRE203	0.000	0	3/2/15	36.89	0.36	18937
707	Grevy's zebra	GRE204	0.000	0	3/4/15	36.90	0.35	21954
708	Grevy's zebra	GRE206	0.000	0	3/4/15	36.89	0.36	24767
709	Grevy's zebra	GRE209	0.000	0	3/7/15	36.92	0.40	24076
710	Grevy's zebra	GRE21	0.000	0	7/4/13	36.92	0.37	7081
711	Grevy's zebra	GRE210	0.000	0	3/7/15	36.92	0.40	17697
712	Grevy's zebra	GRE211	0.000	0	3/10/15	36.89	0.37	8953
713	Grevy's zebra	GRE212	0.000	0	3/13/15	36.92	0.39	10606
714	Grevy's zebra	GRE213	0.000	0	3/13/15	36.92	0.38	12717
715	Grevy's zebra	GRE214	0.000	0	3/13/15	36.92	0.38	9817
716	Grevy's zebra	GRE216	0.000	0	3/11/15	36.86	0.30	11314
717	Grevy's zebra	GRE217	0.000	0	3/13/15	36.87	0.30	12420
718	Grevy's zebra	GRE218	0.000	0	3/13/15	36.87	0.30	11416
719	Grevy's zebra	GRE219	0.000	0	3/13/15	36.88	0.29	12435
720	Grevy's zebra	GRE22	0.000	0	7/4/13	36.90	0.29	5693
721	Grevy's zebra	GRE220	0.000	0	3/14/15	36.87	0.32	10185
722	Grevy's zebra	GRE221	0.000	0	3/14/15	36.87	0.32	35724
723	Grevy's zebra	GRE222	0.000	0	3/14/15	36.87	0.32	68599
724	Grevy's zebra	GRE224	0.000	0	3/15/15	36.89	0.28	44240
725	Grevy's zebra	GRE225	0.000	0	3/16/15	36.90	0.29	52254
726	Grevy's zebra	GRE226	0.000	0	3/16/15	36.88	0.29	35703
727	Grevy's zebra	GRE227	0.000	0	3/16/15	36.88	0.30	64704
728	Grevy's zebra	GRE229	0.000	0	3/17/15	36.88	0.28	59712
729	Grevy's zebra	GRE23	0.000	0	7/4/13	36.90	0.29	10250
730	Grevy's zebra	GRE230	0.000	0	3/18/15	36.86	0.32	48896
731	Grevy's zebra	GRE24_R	0.000	0	7/5/13	36.89	0.35	8169
732	Grevy's zebra	GRE25_R	0.000	0	7/8/13	36.88	0.36	8892
733	Grevy's zebra	GRE26_R	0.000	0	7/8/13	36.93	0.37	7895

734	Grevy's zebra	GRE27_R	0.000	0	7/9/13	36.89	0.31	2496
735	Grevy's zebra	GRE28_R	0.000	0	7/10/13	36.86	0.44	5893
736	Grevy's zebra	GRE29_R	0.000	0	7/10/13	36.86	0.44	3609
737	Grevy's zebra	GRE30_R	0.000	0	7/10/13	36.86	0.44	3431
738	Grevy's zebra	GRE31_R	0.000	0	7/10/13	36.86	0.44	4031
739	Grevy's zebra	GRE32_R	0.000	0	7/10/13	36.91	0.34	8564
740	Grevy's zebra	GRE33_R	0.000	0	7/11/13	36.86	0.44	5438
741	Grevy's zebra	GRE34_R	0.000	0	7/12/13	36.88	0.31	6683
742	Grevy's zebra	GRE35_R	0.000	0	7/12/13	36.90	0.35	5207
743	Grevy's zebra	GRE36_R	0.000	0	7/12/13	36.89	0.36	5110
744	Grevy's zebra	GRE37_R	0.000	0	7/13/13	36.92	0.39	5084
745	Grevy's zebra	GRE38_R	0.000	0	7/14/13	36.92	0.38	10259
746	Grevy's zebra	GRE39_R	0.000	0	7/14/13			4467
747	Grevy's zebra	GRE40_R	0.000	0	7/14/13			6692
748	Grevy's zebra	GRE41_R	0.000	0	7/14/13			7185
749	Grevy's zebra	GRE42_R	0.000	0	7/14/13			9244
750	Grevy's zebra	LM0009	0.000	0	7/15/16	36.89	0.29	99253
751	Grevy's zebra	LM0049	0.000	0	7/17/16	36.90	0.30	83760
752	Grevy's zebra	LM0106	0.000	0	7/19/16	36.97	0.33	43596
753	Grevy's zebra	LM0218	0.000	0	7/25/16	36.89	0.41	156448
754	Grevy's zebra	LM0223	0.000	0	7/26/16	36.91	0.33	95365
755	Grevy's zebra	LM0224	0.000	0	7/26/16	36.91	0.33	17400
756	Grevy's zebra	LM0226	0.000	0	7/26/16	36.91	0.33	123654
757	Grevy's zebra	UNZ01	0.000	0	6/28/13	36.89	0.28	5685
758	Hartebeest	HAR215	0.002	1	3/17/15	36.88	0.31	12722
759	Hartebeest	HAR202	0.001	1	3/6/15	36.87	0.27	5826
760	Hartebeest	HAR210	0.001	1	3/16/15	36.88	0.34	22236
761	Hartebeest	HAR216	0.001	1	3/18/15	36.86	0.27	16138
762	Hartebeest	HAR101A	0.000	0	10/31/14	36.88	0.36	75916
763	Hartebeest	HAR102	0.000	0	11/2/14	36.88	0.35	104415
764	Hartebeest	HAR106	0.000	0	11/3/14	36.89	0.37	47944
765	Hartebeest	HAR107	0.000	0	11/3/14	36.89	0.37	51635
766	Hartebeest	HAR108	0.000	0	11/3/14	36.89	0.37	40688
767	Hartebeest	HAR109	0.000	0	11/3/14	36.89	0.37	26938
768	Hartebeest	HAR110	0.000	0	11/4/14	36.88	0.36	53907
769	Hartebeest	HAR111	0.000	0	11/4/14	36.87	0.36	39381
770	Hartebeest	HAR201	0.000	0	3/3/15	36.88	0.34	4112
771	Hartebeest	HAR203	0.000	0	3/15/15	36.88	0.35	5126
772	Hartebeest	HAR204	0.000	0	3/15/15	36.88	0.35	4455

773	Hartebeest	HAR205	0.000	0	3/15/15	36.88	0.35	4702
774	Hartebeest	HAR206	0.000	0	3/15/15	36.88	0.35	3435
775	Hartebeest	HAR207	0.000	0	3/15/15	36.88	0.35	52402
776	Hartebeest	HAR208	0.000	0	3/16/15	36.87	0.28	75030
777	Hartebeest	HAR209	0.000	0	3/16/15	36.87	0.28	12889
778	Hartebeest	HAR211	0.000	0	3/16/15	36.88	0.35	14967
779	Hartebeest	HAR212	0.000	0	3/16/15	36.88	0.35	12282
780	Hartebeest	HAR213	0.000	0	3/16/15	36.88	0.35	16436
781	Hartebeest	HAR214	0.000	0	3/16/15	36.88	0.35	14183
782	Hartebeest	HAR217	0.000	0	3/18/15	36.86	0.27	15064
783	Hartebeest	LM0304	0.000	0	8/2/16	36.90	0.35	114492
784	Hartebeest	LM0305	0.000	0	8/2/16	36.90	0.35	89415
785	Hippo	HIP204	0.001	1	3/7/15	36.91	0.32	3144
786	Hippo	HIP207	0.001	1	3/12/15	36.91	0.32	66282
787	Hippo	HIP210	0.001	1	3/12/15	36.91	0.32	69650
788	Hippo	HIP216	0.001	1	3/18/15	36.91	0.32	43937
789	Hippo	LM0034	0.001	1	7/16/16	36.91	0.32	20069
790	Hippo	HIP201	0.000	0	3/2/15	36.91	0.34	3517
791	Hippo	HIP202	0.000	0	3/5/15	36.91	0.32	5742
792	Hippo	HIP203	0.000	0	3/7/15	36.91	0.32	5756
793	Hippo	HIP205	0.000	0	3/7/15	36.91	0.32	80147
794	Hippo	HIP206	0.000	0	3/12/15	36.91	0.32	74697
795	Hippo	HIP208	0.000	0	3/12/15	36.91	0.32	49658
796	Hippo	HIP209	0.000	0	3/12/15	36.91	0.32	29922
797	Hippo	HIP211	0.000	0	3/12/15	36.91	0.34	58864
798	Hippo	HIP212	0.000	0	3/12/15	36.91	0.34	89776
799	Hippo	HIP213	0.000	0	3/14/15	36.91	0.32	55503
800	Hippo	HIP214	0.000	0	3/18/15	36.91	0.32	35802
801	Hippo	HIP215	0.000	0	3/18/15	36.91	0.32	55179
802	Hippo	LM0033	0.000	0	7/16/16	36.91	0.32	20685
803	Hippo	LM0042	0.000	0	7/16/16	36.91	0.32	31212
804	Hippo	LM0043	0.000	0	7/16/16	36.91	0.32	40128
805	Hippo	LM0151	0.000	0	7/22/16	36.91	0.30	19335
806	Hippo	LM0300	0.000	0	7/26/16	36.88	0.31	134494
807	Hippo	LM0301	0.000	0	7/26/16	36.88	0.31	75927
808	Impala	IMP225	0.045	1	3/14/15	36.90	0.39	126480
809	Impala	IMP213	0.011	1	3/4/15	36.90	0.37	48666
810	Impala	IMP232	0.005	1	3/15/15	36.88	0.35	124954
811	Impala	IMP234	0.005	1	3/15/15	36.88	0.35	67539

812	Impala	IMP36	0.005	1	6/28/13	36.89	0.28	12091
813	Impala	IMP218	0.004	1	3/8/15	36.92	0.38	122605
814	Impala	IMP233	0.004	1	3/15/15	36.88	0.35	121277
815	Impala	IMP235	0.004	1	3/16/15	36.88	0.35	50796
816	Impala	IMP34	0.004	1	6/28/13	36.89	0.29	4680
817	Impala	GGA215	0.003	1	3/13/15	36.89	0.37	8134
818	Impala	IMP216	0.003	1	3/6/15	36.88	0.30	46882
819	Impala	WHO204	0.003	1	3/16/15	36.88	0.35	166224
820	Impala	IMP1	0.002	1	6/24/13	36.89	0.35	3863
821	Impala	IMP203	0.002	1	3/2/15	36.92	0.36	59320
822	Impala	IMP204	0.002	1	3/2/15	36.89	0.28	122712
823	Impala	IMP207	0.002	1	3/3/15	36.92	0.35	105903
824	Impala	IMP211	0.002	1	3/4/15	36.90	0.37	6259
825	Impala	IMP212	0.002	1	3/4/15	36.90	0.37	83916
826	Impala	IMP219	0.002	1	3/8/15	36.92	0.38	87921
827	Impala	IMP223	0.002	1	3/14/15	36.91	0.34	7520
828	Impala	IMP228	0.002	1	3/15/15	36.91	0.30	54006
829	Impala	IMP230	0.002	1	3/15/15	36.91	0.32	73177
830	Impala	IMP236	0.002	1	3/18/15	36.88	0.36	82397
831	Impala	IMP37	0.002	1	6/28/13	36.89	0.28	5211
832	Impala	IMP46	0.002	1	7/10/13	36.86	0.44	15297
833	Impala	WHO205	0.002	1	3/16/15	36.88	0.35	130834
834	Impala	IMP114	0.001	1	11/1/14	36.88	0.31	28089
835	Impala	IMP124	0.001	1	11/3/14	36.90	0.38	65326
836	Impala	IMP202	0.001	1	3/2/15	36.92	0.36	115142
837	Impala	IMP205	0.001	1	3/2/15	36.88	0.29	97527
838	Impala	IMP208	0.001	1	3/3/15	36.92	0.35	111430
839	Impala	IMP209	0.001	1	3/3/15	36.88	0.35	73712
840	Impala	IMP215	0.001	1	3/6/15	36.88	0.30	79380
841	Impala	IMP224	0.001	1	3/14/15	36.91	0.34	4306
842	Impala	IMP226	0.001	1	3/15/15	36.87	0.35	78084
843	Impala	IMP23	0.001	1	6/26/13	36.86	0.43	7014
844	Impala	IMP28	0.001	1	6/27/13	36.91	0.40	7005
845	Impala	IMP35	0.001	1	6/28/13	36.89	0.29	8146
846	Impala	IMP44	0.001	1	7/10/13	36.86	0.44	16589
847	Impala	LM0139	0.001	1	7/20/16	36.96	0.31	35665
848	Impala	GGA221	0.000	0	3/17/15	36.88	0.34	12912
849	Impala	HAR104	0.000	0	11/2/14	36.88	0.35	59777
850	Impala	IMP10	0.000	0	6/25/13	36.87	0.36	20832

851	Impala	IMP101	0.000	0	10/27/14	36.89	0.30	159037
852	Impala	IMP102	0.000	0	10/29/14	36.88	0.36	38262
853	Impala	IMP103	0.000	0	10/29/14	36.87	0.36	33965
854	Impala	IMP104	0.000	0	10/30/14	36.89	0.30	19513
855	Impala	IMP105	0.000	0	10/30/14	36.89	0.30	31323
856	Impala	IMP106	0.000	0	10/30/14	36.89	0.30	98457
857	Impala	IMP107	0.000	0	10/30/14	36.89	0.30	28813
858	Impala	IMP108	0.000	0	10/30/14	36.88	0.31	38560
859	Impala	IMP109	0.000	0	11/1/14	36.88	0.31	33977
860	Impala	IMP11	0.000	0	6/25/13	36.87	0.36	15324
861	Impala	IMP110	0.000	0	11/1/14	36.88	0.31	21344
862	Impala	IMP111	0.000	0	11/1/14	36.88	0.31	41377
863	Impala	IMP112	0.000	0	11/1/14	36.88	0.31	52956
864	Impala	IMP113	0.000	0	11/1/14	36.88	0.31	53668
865	Impala	IMP115	0.000	0	11/1/14	36.89	0.28	32519
866	Impala	IMP116	0.000	0	11/1/14	36.89	0.28	25909
867	Impala	IMP117	0.000	0	11/1/14	36.89	0.28	34562
868	Impala	IMP118	0.000	0	11/1/14	36.89	0.28	28633
869	Impala	IMP119	0.000	0	11/1/14	36.89	0.28	36116
870	Impala	IMP12	0.000	0	6/25/13	36.87	0.36	6567
871	Impala	IMP120	0.000	0	11/2/14	36.88	0.35	39438
872	Impala	IMP121	0.000	0	11/2/14	36.88	0.35	80824
873	Impala	IMP122	0.000	0	11/3/14	36.92	0.35	48185
874	Impala	IMP123	0.000	0	11/3/14	36.92	0.35	35568
875	Impala	IMP125	0.000	0	11/3/14	36.90	0.37	54336
876	Impala	IMP13	0.000	0	6/25/13	36.92	0.37	4093
877	Impala	IMP14	0.000	0	6/25/13	36.92	0.37	5486
878	Impala	IMP15	0.000	0	6/25/13	36.89	0.29	4358
879	Impala	IMP16	0.000	0	6/25/13	36.89	0.29	8542
880	Impala	IMP17	0.000	0	6/26/13	36.86	0.41	4810
881	Impala	IMP18	0.000	0	6/26/13	36.86	0.41	4289
882	Impala	IMP19	0.000	0	6/26/13	36.85	0.43	5822
883	Impala	IMP2	0.000	0	6/24/13	36.90	0.34	9442
884	Impala	IMP20	0.000	0	6/26/13	36.85	0.43	5071
885	Impala	IMP201	0.000	0	3/2/15	36.92	0.36	71747
886	Impala	IMP206	0.000	0	3/3/15	36.88	0.31	132601
887	Impala	IMP21	0.000	0	6/26/13	36.86	0.45	11206
888	Impala	IMP210	0.000	0	3/4/15	36.88	0.35	4759
889	Impala	IMP214	0.000	0	3/6/15	36.88	0.30	62476

890	Impala	IMP217	0.000	0	3/8/15	36.87	0.38	74991
891	Impala	IMP22	0.000	0	6/26/13	36.86	0.43	11237
892	Impala	IMP220	0.000	0	3/10/15	36.91	0.40	78118
893	Impala	IMP221	0.000	0	3/10/15	36.91	0.40	57297
894	Impala	IMP222	0.000	0	3/14/15	36.91	0.34	88437
895	Impala	IMP227	0.000	0	3/15/15	36.91	0.30	11821
896	Impala	IMP229	0.000	0	3/15/15	36.91	0.30	38858
897	Impala	IMP231	0.000	0	3/15/15	36.91	0.32	67129
898	Impala	IMP24	0.000	0	6/26/13	36.86	0.43	7640
899	Impala	IMP25	0.000	0	6/26/13	36.89	0.28	18074
900	Impala	IMP26	0.000	0	6/26/13	36.89	0.29	7330
901	Impala	IMP27	0.000	0	6/26/13	36.89	0.29	4044
902	Impala	IMP29	0.000	0	6/27/13	36.91	0.40	3654
903	Impala	IMP3	0.000	0	6/24/13	36.90	0.34	18813
904	Impala	IMP30	0.000	0	6/27/13	36.91	0.40	5905
905	Impala	IMP31	0.000	0	6/27/13	36.88	0.31	4065
906	Impala	IMP32	0.000	0	6/28/13	36.89	0.29	6032
907	Impala	IMP33	0.000	0	6/28/13	36.89	0.29	6003
908	Impala	IMP38	0.000	0	6/28/13	36.89	0.28	7196
909	Impala	IMP39	0.000	0	6/28/13	36.90	0.36	5432
910	Impala	IMP4	0.000	0	6/24/13	36.90	0.34	21552
911	Impala	IMP40	0.000	0	6/28/13	36.90	0.36	10623
912	Impala	IMP41	0.000	0	6/28/13	36.90	0.36	4875
913	Impala	IMP42	0.000	0	7/10/13	36.90	0.43	13958
914	Impala	IMP43	0.000	0	7/10/13	36.86	0.48	11025
915	Impala	IMP45	0.000	0	7/10/13	36.86	0.44	11157
916	Impala	IMP47	0.000	0	7/10/13	36.86	0.44	9481
917	Impala	IMP5	0.000	0	6/24/13	36.90	0.34	15185
918	Impala	IMP50	0.000	0	7/10/13	36.86	0.40	42212
919	Impala	IMP6	0.000	0	6/24/13	36.89	0.28	12812
920	Impala	IMP7	0.000	0	6/24/13	36.89	0.28	15686
921	Impala	IMP8	0.000	0	6/24/13	36.89	0.28	14971
922	Impala	IMP9	0.000	0	6/25/13	36.87	0.36	7991
923	Impala	LM0013	0.000	0	7/15/16	36.89	0.29	123890
924	Impala	LM0014	0.000	0	7/15/16	36.89	0.29	95031
925	Impala	LM0015	0.000	0	7/15/16	36.89	0.29	105219
926	Impala	LM0016	0.000	0	7/15/16	36.89	0.29	151976
927	Impala	LM0017	0.000	0	7/15/16	36.87	0.34	73499
928	Impala	LM0018	0.000	0	7/15/16	36.87	0.34	92095

929	Impala	LM0019	0.000	0	7/15/16	36.87	0.34	189958
930	Impala	LM0020	0.000	0	7/15/16	36.87	0.34	191787
931	Impala	LM0093	0.000	0	7/19/16	36.99	0.33	67083
932	Impala	LM0097	0.000	0	7/19/16	36.99	0.33	8764
933	Impala	LM0145	0.000	0	7/21/16	36.90	0.34	11400
934	Impala	LM0155	0.000	0	7/22/16	36.91	0.32	48434
935	Impala	LM0203	0.000	0	7/25/16	36.88	0.39	123441
936	Impala	LM0296	0.000	0	7/10/16	36.87	0.34	73865
937	Kudu	KUD204	0.005	1	3/5/15	36.91	0.32	38857
938	Kudu	KUD213	0.004	1	3/15/15	36.91	0.32	59635
939	Kudu	KUD211	0.003	1	3/14/15	36.91	0.31	92855
940	Kudu	KUD215	0.003	1	3/15/15	36.91	0.32	72696
941	Kudu	KUD202	0.002	1	3/3/15	36.91	0.32	134461
942	Kudu	KUD203	0.002	1	3/5/15	36.91	0.32	50741
943	Kudu	KUD205	0.002	1	3/7/15	36.91	0.29	48001
944	Kudu	KUD206	0.002	1	3/12/15	36.91	0.32	67570
945	Kudu	KUD207	0.002	1	3/12/15	36.91	0.32	57289
946	Kudu	KUD208	0.002	1	3/12/15	36.91	0.32	66279
947	Kudu	KUD209	0.002	1	3/12/15	36.91	0.32	47315
948	Kudu	KUD210	0.002	1	3/12/15	36.91	0.32	94011
949	Kudu	KUD212	0.002	1	3/14/15	36.91	0.31	91104
950	Kudu	KUD201	0.001	1	3/2/15	36.91	0.31	12038
951	Kudu	KUD214	0.001	1	3/15/15	36.91	0.32	75583
952	Kudu	LM0271	0.001	1	7/29/16			4282
953	Kudu	KUD101	0.000	0	10/26/14	36.91	0.32	7313
954	Kudu	KUD102	0.000	0	10/27/14	36.91	0.31	41042
955	Kudu	KUD103	0.000	0	10/27/14	36.91	0.31	63659
956	Kudu	KUD104	0.000	0	10/27/14	36.91	0.31	64476
957	Kudu	KUD105	0.000	0	10/27/14	36.91	0.31	44200
958	Kudu	KUD106	0.000	0	10/27/14	36.91	0.31	38413
959	Kudu	KUD107	0.000	0	10/30/14	36.91	0.31	122664
960	Kudu	KUD108	0.000	0	11/3/14	36.91	0.32	71567
961	Kudu	KUD109	0.000	0	11/3/14	36.91	0.32	31146
962	Kudu	LM0234	0.000	0	7/27/16	36.91	0.32	152512
963	Kudu	LM0272	0.000	0	7/29/16			191351
964	Kudu	LM0307	0.000	0	8/3/16	36.91	0.32	67930
965	Oryx	ORX201	0.002	1	3/3/15	36.86	0.32	7110
966	Oryx	GGA216	0.001	1	3/13/15	36.86	0.30	11849
967	Oryx	LM0105	0.001	1	7/19/16	36.97	0.33	10736

968	Oryx	ORX101	0.001	1	10/26/14	36.88	0.35	59061
969	Oryx	ORX104	0.001	1	11/4/14	36.88	0.32	95776
970	Oryx	LM0103	0.000	0	7/19/16	36.95	0.36	10267
971	Oryx	LM0104	0.000	0	7/19/16	36.95	0.36	8327
972	Oryx	LM0135	0.000	0	7/20/16	36.96	0.31	23891
973	Oryx	LM0136	0.000	0	7/20/16	36.96	0.31	9018
974	Oryx	LM0137	0.000	0	7/20/16	36.96	0.31	42286
975	Oryx	LM0138	0.000	0	7/20/16	36.96	0.31	1744
976	Oryx	LM0235	0.000	0	7/27/16	36.88	0.32	53721
977	Oryx	LM0261	0.000	0	7/29/16	36.88	0.32	64127
978	Oryx	LM0262	0.000	0	7/29/16	36.88	0.32	111104
979	Oryx	LM0263	0.000	0	7/29/16	36.88	0.32	4833
980	Oryx	LM0264	0.000	0	7/29/16	36.88	0.32	25382
981	Oryx	ORX102	0.000	0	11/4/14	36.88	0.32	19948
982	Oryx	ORX103	0.000	0	11/4/14	36.88	0.32	67055
983	Oryx	ORX105	0.000	0	11/4/14	36.88	0.32	84785
984	Oryx	ORX106	0.000	0	11/4/14	36.88	0.32	26965
985	Oryx	ORX107	0.000	0	11/4/14	36.88	0.32	39074
986	Oryx	WHO203	0.000	0	3/16/15	36.88	0.35	74423
987	Plains zebra	PLA236	0.003	1	3/16/15	36.86	0.31	88030
988	Plains zebra	LM0229	0.001	1	7/26/16	36.88	0.31	19228
989	Plains zebra	PLA106	0.001	1	10/29/14	36.87	0.35	96280
990	Plains zebra	PLA207	0.001	1	3/6/15	36.88	0.35	74575
991	Plains zebra	PLA237	0.001	1	3/18/15	36.86	0.32	49392
992	Plains zebra	LM0055	0.000	0	7/18/16	37.02	0.33	135070
993	Plains zebra	LM0073	0.000	0	7/18/16	37.07	0.27	105516
994	Plains zebra	LM0074	0.000	0	7/18/16	37.07	0.27	173093
995	Plains zebra	LM0076	0.000	0	7/18/16	37.06	0.28	72975
996	Plains zebra	LM0081	0.000	0	7/18/16	36.95	0.29	248590
997	Plains zebra	LM0098	0.000	0	7/19/16	36.99	0.33	19989
998	Plains zebra	LM0200	0.000	0	7/24/16	36.90	0.36	228458
999	Plains zebra	LM0215	0.000	0	7/25/16	36.88	0.40	28027
1000	Plains zebra	LM0295	0.000	0	7/10/16	36.88	0.30	204663
1001	Plains zebra	PLA01	0.000	0	6/27/13	36.88	0.36	8832
1002	Plains zebra	PLA02	0.000	0	6/27/13	36.88	0.36	6600
1003	Plains zebra	PLA03	0.000	0	6/27/13	36.88	0.36	9531
1004	Plains zebra	PLA04	0.000	0	6/27/13	36.88	0.36	14426
1005	Plains zebra	PLA05	0.000	0	6/27/13	36.88	0.36	8966
1006	Plains zebra	PLA06	0.000	0	6/27/13	36.88	0.31	6288

1007	Plains zebra	PLA07	0.000	0	6/27/13	36.88	0.31	12120
1008	Plains zebra	PLA08	0.000	0	6/27/13	36.88	0.31	12789
1009	Plains zebra	PLA09	0.000	0	6/27/13	36.88	0.31	9635
1010	Plains zebra	PLA10	0.000	0	6/27/13	36.88	0.31	8840
1011	Plains zebra	PLA101	0.000	0	10/26/14	36.88	0.35	73053
1012	Plains zebra	PLA102	0.000	0	10/27/14	36.90	0.36	102842
1013	Plains zebra	PLA103	0.000	0	10/27/14	36.90	0.36	75735
1014	Plains zebra	PLA104	0.000	0	10/28/14	36.86	0.36	56925
1015	Plains zebra	PLA105	0.000	0	10/28/14	36.86	0.36	60585
1016	Plains zebra	PLA107	0.000	0	10/29/14	36.87	0.30	74782
1017	Plains zebra	PLA108	0.000	0	10/29/14	36.87	0.30	90412
1018	Plains zebra	PLA109	0.000	0	10/30/14	36.89	0.31	93595
1019	Plains zebra	PLA11	0.000	0	6/27/13	36.88	0.31	12575
1020	Plains zebra	PLA110	0.000	0	10/30/14	36.89	0.31	96518
1021	Plains zebra	PLA111	0.000	0	10/30/14	36.88	0.31	52209
1022	Plains zebra	PLA112	0.000	0	10/30/14	36.88	0.36	39513
1023	Plains zebra	PLA113	0.000	0	11/2/14	36.89	0.28	42703
1024	Plains zebra	PLA114	0.000	0	11/2/14	36.89	0.28	50236
1025	Plains zebra	PLA115	0.000	0	11/2/14	36.89	0.28	51081
1026	Plains zebra	PLA116	0.000	0	11/2/14	36.89	0.28	33875
1027	Plains zebra	PLA117	0.000	0	11/2/14	36.89	0.35	74893
1028	Plains zebra	PLA118	0.000	0	11/2/14	36.89	0.35	42535
1029	Plains zebra	PLA12	0.000	0	6/28/13	36.89	0.28	8639
1030	Plains zebra	PLA13	0.000	0	6/28/13	36.88	0.31	12264
1031	Plains zebra	PLA14	0.000	0	6/28/13	36.88	0.31	10072
1032	Plains zebra	PLA15	0.000	0	6/28/13	36.89	0.35	9655
1033	Plains zebra	PLA16	0.000	0	7/2/13	36.88	0.36	7384
1034	Plains zebra	PLA17	0.000	0	7/2/13	36.88	0.36	9929
1035	Plains zebra	PLA18_R	0.000	0	7/3/13	36.88	0.32	9580
1036	Plains zebra	PLA19	0.000	0	7/3/13	36.88	0.30	7260
1037	Plains zebra	PLA20	0.000	0	7/3/13	36.88	0.30	10178
1038	Plains zebra	PLA201	0.000	0	3/2/15	36.89	0.36	88262
1039	Plains zebra	PLA202	0.000	0	3/4/15	36.86	0.32	97059
1040	Plains zebra	PLA203	0.000	0	3/4/15	36.86	0.32	56313
1041	Plains zebra	PLA204	0.000	0	3/4/15	36.86	0.32	89884
1042	Plains zebra	PLA205	0.000	0	3/4/15	36.87	0.33	91128
1043	Plains zebra	PLA206	0.000	0	3/6/15	36.88	0.35	95989
1044	Plains zebra	PLA208	0.000	0	3/13/15	36.88	0.34	126293
1045	Plains zebra	PLA209	0.000	0	3/13/15	36.88	0.34	80890

1046	Plains zebra	PLA21	0.000	0	7/4/13	36.89	0.34	11090
1047	Plains zebra	PLA210	0.000	0	3/11/15	36.90	0.35	33532
1048	Plains zebra	PLA211	0.000	0	3/11/15	36.87	0.33	75797
1049	Plains zebra	PLA212	0.000	0	3/11/15	36.87	0.33	33444
1050	Plains zebra	PLA213	0.000	0	3/11/15	36.87	0.33	32383
1051	Plains zebra	PLA214	0.000	0	3/11/15	36.90	0.36	21799
1052	Plains zebra	PLA215	0.000	0	3/11/15	36.90	0.35	25987
1053	Plains zebra	PLA216	0.000	0	3/11/15	36.90	0.36	18518
1054	Plains zebra	PLA217	0.000	0	3/11/15	36.90	0.35	23215
1055	Plains zebra	PLA218	0.000	0	3/11/15	36.88	0.36	31052
1056	Plains zebra	PLA219	0.000	0	3/13/15	36.89	0.39	20713
1057	Plains zebra	PLA22	0.000	0	7/5/13	36.89	0.32	8855
1058	Plains zebra	PLA220	0.000	0	3/13/15	36.89	0.39	9896
1059	Plains zebra	PLA221	0.000	0	3/13/15	36.89	0.39	14652
1060	Plains zebra	PLA222	0.000	0	3/13/15	36.89	0.39	12969
1061	Plains zebra	PLA223	0.000	0	3/13/15	36.87	0.30	9911
1062	Plains zebra	PLA224	0.000	0	3/13/15	36.87	0.30	12309
1063	Plains zebra	PLA225	0.000	0	3/13/15	36.87	0.30	8831
1064	Plains zebra	PLA226	0.000	0	3/14/15	36.90	0.39	11861
1065	Plains zebra	PLA227	0.000	0	3/14/15	36.88	0.39	14071
1066	Plains zebra	PLA228	0.000	0	3/14/15	36.88	0.40	12278
1067	Plains zebra	PLA229	0.000	0	3/14/15	36.89	0.39	10454
1068	Plains zebra	PLA23	0.000	0	7/5/13	36.88	0.37	9347
1069	Plains zebra	PLA230	0.000	0	3/14/15	36.89	0.39	17664
1070	Plains zebra	PLA231	0.000	0	3/14/15	36.87	0.32	10628
1071	Plains zebra	PLA232	0.000	0	3/14/15	36.87	0.32	65455
1072	Plains zebra	PLA233	0.000	0	3/14/15	36.87	0.32	90570
1073	Plains zebra	PLA234	0.000	0	3/15/15	36.88	0.39	74516
1074	Plains zebra	PLA235	0.000	0	3/16/15	36.86	0.31	59889
1075	Plains zebra	PLA24	0.000	0	7/5/13	36.88	0.32	7772
1076	Plains zebra	PLA25_R	0.000	0	7/8/13	36.88	0.36	6194
1077	Plains zebra	PLA26_R	0.000	0	7/9/13	36.88	0.36	7598
1078	Plains zebra	PLA27_R	0.000	0	7/10/13	36.87	0.48	20224
1079	Plains zebra	PLA28_R	0.000	0	7/10/13	36.93	0.37	5068
1080	Plains zebra	PLA29_R	0.000	0	7/11/13	36.87	0.36	7447
1081	Plains zebra	PLA30_R	0.000	0	7/11/13	36.91	0.34	9269
1082	Plains zebra	PLA31_R	0.000	0	7/12/13	36.89	0.36	8236
1083	Plains zebra	PLA32_R	0.000	0	7/15/13	36.91	0.40	8737
1084	Plains zebra	PLA33_R	0.000	0	7/15/13			12358

1085	Plains zebra	PLA34_R	0.000	0	7/15/13			9175
1086	Plains zebra	PLA35_R	0.000	0	7/16/13			4772
1087	Plains zebra	PLA36_R	0.000	0	7/16/13			13846
1088	Plains zebra	PLA37_R	0.000	0	7/16/13			9656
1089	Plains zebra	PLA38_R	0.000	0	7/16/13			10644
1090	Plains zebra	PLA39_R	0.000	0	7/16/13			7740
1091	Plains zebra	PLA40_R	0.000	0	7/16/13			13097
1092	Plains zebra	PLA41_R	0.000	0	7/16/13			10951
1093	Sheep	SHE211	0.003	1	3/7/15	36.89	0.32	73143
1094	Sheep	LM0188	0.002	1	7/24/16	36.87	0.36	37491
1095	Sheep	SHE118_R	0.002	1	11/2/14	36.87	0.34	2356
1096	Sheep	SHE119_R	0.002	1	11/2/14	36.87	0.34	27986
1097	Sheep	LM0192	0.001	1	7/24/16	36.87	0.36	72266
1098	Sheep	SHE104	0.001	1	10/29/14	36.87	0.34	34915
1099	Sheep	SHE113	0.001	1	11/2/14	36.87	0.34	52024
1100	Sheep	SHE203	0.001	1	3/7/15	36.89	0.32	52463
1101	Sheep	SHE206	0.001	1	3/7/15	36.89	0.32	60891
1102	Sheep	SHE208	0.001	1	3/7/15	36.89	0.32	62256
1103	Sheep	LM0165	0.000	0	7/22/16	36.90	0.32	3830
1104	Sheep	LM0166	0.000	0	7/22/16	36.90	0.32	8082
1105	Sheep	LM0167	0.000	0	7/22/16	36.90	0.32	41645
1106	Sheep	LM0168	0.000	0	7/22/16	36.90	0.32	5416
1107	Sheep	LM0169	0.000	0	7/22/16	36.90	0.32	133276
1108	Sheep	LM0170	0.000	0	7/22/16	36.90	0.32	21627
1109	Sheep	LM0171	0.000	0	7/22/16	36.90	0.32	53279
1110	Sheep	LM0172	0.000	0	7/22/16	36.90	0.32	29551
1111	Sheep	LM0173	0.000	0	7/22/16	36.90	0.32	7860
1112	Sheep	LM0174	0.000	0	7/22/16	36.90	0.32	8431
1113	Sheep	LM0187	0.000	0	7/24/16	36.87	0.36	97187
1114	Sheep	LM0189	0.000	0	7/24/16	36.87	0.36	29205
1115	Sheep	LM0190	0.000	0	7/24/16	36.87	0.36	26294
1116	Sheep	LM0191	0.000	0	7/24/16	36.87	0.36	4924
1117	Sheep	LM0193	0.000	0	7/24/16	36.87	0.36	128799
1118	Sheep	LM0194	0.000	0	7/24/16	36.87	0.36	2966
1119	Sheep	LM0311	0.000	0	8/3/16	36.88	0.36	111747
1120	Sheep	SHE101	0.000	0	10/29/14	36.87	0.34	51677
1121	Sheep	SHE102	0.000	0	10/29/14	36.87	0.34	27523
1122	Sheep	SHE103	0.000	0	10/29/14	36.87	0.34	40346
1123	Sheep	SHE105	0.000	0	10/29/14	36.87	0.34	36292

1124	Sheep	SHE106	0.000	0	10/29/14	36.87	0.34	25503
1125	Sheep	SHE107	0.000	0	10/29/14	36.87	0.34	40264
1126	Sheep	SHE108	0.000	0	10/29/14	36.87	0.34	26437
1127	Sheep	SHE109	0.000	0	10/29/14	36.87	0.34	77055
1128	Sheep	SHE110	0.000	0	10/29/14	36.87	0.34	54982
1129	Sheep	SHE111	0.000	0	10/29/14	36.87	0.34	50033
1130	Sheep	SHE112	0.000	0	11/2/14	36.87	0.34	59128
1131	Sheep	SHE114	0.000	0	11/2/14	36.87	0.34	106958
1132	Sheep	SHE115	0.000	0	11/2/14	36.87	0.34	75838
1133	Sheep	SHE120_R	0.000	0	11/2/14	36.87	0.34	24252
1134	Sheep	SHE201	0.000	0	3/7/15	36.89	0.32	68432
1135	Sheep	SHE202	0.000	0	3/7/15	36.89	0.32	89734
1136	Sheep	SHE204	0.000	0	3/7/15	36.89	0.32	47419
1137	Sheep	SHE205	0.000	0	3/7/15	36.89	0.32	71299
1138	Sheep	SHE207	0.000	0	3/7/15	36.89	0.32	51674
1139	Sheep	SHE209	0.000	0	3/7/15	36.89	0.32	63451
1140	Sheep	SHE210	0.000	0	3/7/15	36.89	0.32	46855
1141	Warthog	WAR201	0.002	1	3/4/15	36.89	0.36	9005
1142	Warthog	WHO103	0.002	1	3/18/15	36.89	0.30	105052
1143	Warthog	LM0157	0.001	1	7/22/16	36.89	0.31	25630
1144	Warthog	LM0158	0.001	1	7/22/16	36.89	0.31	33540
1145	Warthog	WAR105	0.001	1	10/29/14	36.87	0.36	88516
1146	Warthog	LM0148	0.000	0	7/21/16	36.87	0.37	90970
1147	Warthog	LM0149	0.000	0	7/21/16	36.86	0.34	7966
1148	Warthog	LM0156	0.000	0	7/22/16	36.89	0.31	52300
1149	Warthog	LM0159	0.000	0	7/22/16	36.89	0.31	35635
1150	Warthog	LM0160	0.000	0	7/22/16	36.89	0.31	127799
1151	Warthog	LM0161	0.000	0	7/22/16	36.89	0.31	4512
1152	Warthog	LM0230	0.000	0	7/27/16	36.87	0.36	9107
1153	Warthog	LM0244	0.000	0	7/28/16	36.89	0.28	47427
1154	Warthog	LM0245	0.000	0	7/28/16	36.89	0.28	5383
1155	Warthog	WAR101	0.000	0	10/28/14	36.87	0.36	66715
1156	Warthog	WAR102	0.000	0	10/28/14	36.87	0.36	71209
1157	Warthog	WAR103	0.000	0	10/28/14	36.87	0.36	21820
1158	Warthog	WAR104	0.000	0	10/29/14	36.87	0.36	55251
1159	Warthog	WAR106	0.000	0	10/29/14	36.87	0.36	34869
1160	Warthog	WAR107	0.000	0	10/30/14	36.88	0.31	19283
1161	Warthog	WAR108	0.000	0	10/30/14	36.88	0.31	50328
1162	Warthog	WAR109	0.000	0	10/30/14	36.88	0.31	39981

1163	Warthog	WAR110	0.000	0	10/30/14	36.88	0.31	61554
1164	Warthog	WAR111	0.000	0	11/1/14	36.88	0.35	116562
1165	Warthog	WAR202	0.000	0	3/10/15	36.88	0.36	10429
1166	Warthog	WAR203	0.000	0	3/10/15	36.88	0.36	2140
1167	Warthog	WAR204	0.000	0	3/10/15	36.90	0.28	17324
1168	Warthog	WAR205	0.000	0	3/13/15	36.88	0.32	1882
1169	Warthog	WAR206	0.000	0	3/18/15	36.90	0.36	17874
1170	Warthog	WHO101	0.000	0	10/27/14	36.88	0.31	48449
1171	Waterbuck	ELA203	0.002	1	3/8/15	36.90	0.29	9590
1172	Waterbuck	LM0026	0.001	1	7/16/16	36.91	0.29	162616
1173	Waterbuck	LM0027	0.001	1	7/16/16	36.91	0.29	216227
1174	Waterbuck	LM0029	0.001	1	7/16/16	36.91	0.28	196627
1175	Waterbuck	WAT101	0.001	1	11/5/14	36.90	0.33	65504
1176	Waterbuck	WAT102	0.000	0	11/5/14	36.90	0.29	59936

Legends for Movies S1 to S4.

Movie S1 (separate file). Elephant eating transplanted *Cynanchum*.

Movie S2 (separate file). Giraffe eating transplanted *Cynanchum*.

Movie S3 (separate file). Impala eating transplanted *Cynanchum*.

Movie S4 (separate file). Eland eating transplanted *Cynanchum*.

List of data deposited in Dryad.

The following data files are available on Dryad (reference S4). The original DNA-metabarcoding data underlying Fig. 1E and Tables S1 and S2 are archived separately in Dryad (reference S3).

- 1) Cafeteria trial data (data underlying Fig. 1F; Feeding_Trial.csv)
- 2) Desiccation trial data (no corresponding figure; Desiccation_Trial.csv)
- 3) UHURU liana prevalence surveys (data underlying Fig. 2 A, C, and D; UHURU_Liana_Survey.csv)
- 4) UHURU transect surveys (data underlying Fig. 2 E and F; UHURU_Transect_Survey.csv)
- 5) UHURU tree survey (data underlying Fig. 2B; UHURU_Tree_Biomass_and_Density.csv)
- 6) GLADE liana prevalence and effects of herbivore reintroduction (data underlying Fig. 3; GLADE_Liana_Prevalence_And_Herbivore_Reintroduction_Survey.csv)
- 7) Liana growth surveys (no corresponding figure; Liana_Growth_Survey.csv)
- 8) Liana-removal experiment (data underlying Fig. 4A; Liana_Removal_Experiment.csv)
- 9) Tree reproductive survey (data underlying Fig. 4B; Acacia_Reproductive_Survey.csv)
- 10) UHURU 2018 canopy-intercept survey (data underlying Fig. S1 A and B; UHURU_Canopy_Intercept_Survey.csv)
- 11) UHURU Cynanchum understory survey (data underlying Fig. S1 C and D; UHURU_Cynanchum_Understory_Survey.csv)

SI References

- S1. T. R. Kartzinel, J. C. Hsing, P. M. Musili, B. R. P. Brown, R. M. Pringle, Covariation of diet and gut microbiome in African megafauna. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 23588–23593 (2019).
- S2. T. R. Kartzinel, R. M. Pringle, Multiple dimensions of dietary diversity in large mammalian herbivores. *J. Anim. Ecol.* **89**, 1482–1496 (2020).
- S3. T. R. Kartzinel, J. C. Hsing, P. M. Musili, R. M. Pringle, Data from: Covariation of diet and gut microbiome in African megafauna. *Dryad Digital Repository*, <https://doi.org/10.5061/dryad.c119gm5> (2020).
- S4. T. C. Coverdale et al., Data from: Large herbivores suppress liana infestation in an African savanna. *Dryad Digital Repository*, <https://doi.org/10.5061/dryad.gmsbcc2np> (2021).