Accepted: 7 February 2018
DOI: 10.1002/geo2.53

RESEARCH ARTICLE

Effects of livestock grazing on *Anemone coronaria* L. in drylands: Implications for nature conservation

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Funding information
Yad Hanadiv Foundation, Grant/Award Number: NA

Grazing in nature reserves, or other sensitive lands, could affect the abundance of important plant species. In the Mediterranean basin, the *Anemone coronaria* is considered a flagship geophyte species. Studies conducted in the Mediterranean region of northern Israel showed that livestock grazing increased the abundance of *A. coronaria*. This was attributed to the consumption of other herbaceous vegetation species, resulting in better accessibility of *A. coronaria* to sunlight. Also, it was suggested that consumption of this species is limited due to its toxicity. The objective of this study was to investigate the impact of livestock on the abundance of *A. coronaria,* and on specific soil properties in a dryland environment, where primary productivity is determined by water availability. A long-term study was established in the Israeli Negev, where early-, mid-, and late-season grazing treatments took place over the course of a decade, and studied over three consecutive years between 2013/2014 and 2015/2016. The study revealed that the abundance of *A. coronaria* followed the order of non-grazing (control) > late-season grazing > mid-season grazing > early-season grazing. However, this effect was not significant (p = .0668). One way or another, the largest adverse impact of early-season grazing is attributed to consuming fresh and not yet toxic shoots of *A. coronaria* at that phenological stage. The soil properties were studied in summer 2016. The analysis showed a significant increase in bulk density under all of the grazing treatments compared with those in the control plots. It was concluded that, in drylands, trampling over wet soil during the growing season increases its compactability, degrading the soil-moisture status, and limiting *A. coronaria* abundance. Recommendations for nature conservation in drylands are, therefore, to negate grazing during *A. coronaria*'s early-growing season, as well as shortly after rain events when the soil moisture level is high.

KEYWORDS
digestion inhibitors, hoof impact, non-palatable biochemicals, semi-arid environment, soil compaction and deformation, soil quality

1 | INTRODUCTION

Degradation of drylands affects vast areas around the world (Sparrow et al., 2003). This process has been exacerbated because of anthropogenic misuse of drylands, which are home to 50% of the world's livestock (Davies et al., 2016).

Indeed, among the causes of land degradation, mismanagement of rangelands is predominant. Yet, the geo-ecological impacts of livestock grazing are still questionable. For example, for the drylands of South Africa, Hanke et al. (2014) reported no clear effect of grazing intensity on plant species diversity, suggesting the need for more elaborate indicators to assess livestock impact. At the same time, in the grazing lands of central Australia, it was reported that livestock grazing has resulted in considerable modifications in plant composition, with a decrease in palatable herbaceous vegetation species, and an increase in non-palatable herbaceous vegetation (Sparrow et al., 2003). However, it was also reported that in the very same Australian study site, vegetation cover and composition were related mainly to pedogenic and geomorphic strata, rather than to grazing regime (Friedel et al., 2003).

For the same Australian site it was reported that heavy grazing intensity has caused the breakdown of biological crusts, resulting in soil erosion and a decrease in soil organic carbon pools (Tongway et al., 2003). Though conducted under moister conditions, a study by Cournane et al. (2013) in southern New Zealand reported differences in impact on soil quality between cattle and sheep, with the cattle imposing a more adverse effect than that caused by sheep. Regardless of animal type, in the same study it was reported that the greatest impact of the grazing animals on water runoff generation and soil erosion occurred in winter, when soil moisture was at or above field capacity. At the same time, for a Chinese steppe region, Chen et al. (2015) reported that constant moderate grazing has caused high productivity of roots with a fast turnover rate, leading to high soil organic carbon pools.

The specific impacts of livestock grazing on geophytes are even more controversial. For example, in a study the Mediterranean region of in northern Israel, Noy-Meir and Oron (2001) studied the effect of cattle on 22 geophyte species. Overall, they reported that nine species were positively affected by grazing, while for the rest of the species, the effect of livestock was not consistent. Also, they reported that the positive effect of grazing on geophyte diversity was lower in sites with low productivity. Specifically, populations of *Anemone coronaria* L., which is considered a flagship geophyte species in Israel, have been reported to increase (Perevolotsky et al., 2011), remain unaffected or decrease (Noy-Meir & Oron, 2001) in lands prone to grazing. The increase in abundance of *A. coronaria* in rangelands was associated with the toxicity of its protoanemonin and anemonin content (Keasar et al., 2012; Knight & Walter, 2001), which regulates its consumption by livestock (Wink, 2009). The simultaneous consumption of other herbaceous vegetation species increases the *A. coronaria*'s accessibility to sunlight, which is limited during the growing season (Perevolotsky et al., 2011). An alternative explanation to this effect is the subterranean regeneration buds that define geophytes, making them less vulnerable to grazing by livestock. In rangelands, this increases the abundance of geophytes compared with other perennial plants (such as hemicryptophytes or chamaephytes) that have aboveground buds, or to annuals that regenerate by seeds (Hadar et al., 1999). Regardless, a possible mechanism for the negative effect of livestock was suggested to be the trampling action (Noy-Meir & Oron, 2001) that demolishes shoots of *A. coronaria*.

The above-mentioned studies, revealing the different and sometimes contradictory impacts of livestock grazing, suggest that the effects are not straightforward and therefore require additional research. Further, while these studies were conducted under the Mediterranean climatic conditions that prevail in northern Israel – where sunlight might indeed be a limiting factor during the winter to spring growing season – an understanding of livestock impact on *A. coronaria* in drylands is still missing.

Therefore, the major objective of this study was to assess the effect of livestock grazing on the abundance of *A. coronaria* in a dryland region by recording the number of flowers for this species. The secondary objectives were (1) to investigate how the timing of grazing throughout the growing season impacts *A. coronaria*; and (2) to assess the effect of livestock treatments on some key soil properties which indicate its quality. The rationale behind these objectives was to examine the possible use of livestock grazing as a management tool, which could help in achieving certain nature conservation goals. The major study hypothesis was that, while other vegetation species might be consumed by livestock, the toxicity of *A. coronaria* would result in an increase in abundance of this geophyte species. Secondary hypotheses were that (1) due to an assumed increase in toxicity of *A. coronaria* over the growing season, the positive effect of livestock on *A. coronaria* would be the smallest and greatest for early- and late-season grazing, respectively; and (2) soil compaction by livestock hooves degrades the soil quality, determining the soil-moisture status, and regulating the abundance of *A. coronaria*.

2 | MATERIALS AND METHODS

2.1 | *A. coronaria*: Lifeform, ecology, morphology and propagation

The genus *Anemone* belongs to the Ranunculaceae family. *A. coronaria* mostly characterises Mediterranean shrublands and maquis ecosystems. The species is a perennial geophyte, which is dormant during the dry season and regenerates annually from tubers. An individual spends its two-first years in juvenility, and has a lifespan of up to 10 years (Horovitz et al., 1975). Both dormancy and flowering are controlled by temperature and length of daylight (Ben-Hod et al., 1988). The species blooms in winter and spring (December–March), with the blooming peak in February. In colder regions, it can also bloom in April (Horovitz et al., 1975).

Anemone coronaria has leaves with long petioles, and one to some flower stalks. Each flower has five or more petaloid sepals, many stamens, and one ovulated carpel (Horovitz et al., 1975). The flower has a simple perianth, without sepals. The petals are large and thin. Their number is not fixed, but usually ranges between five and six. The colour of the flowers is bright red or white, or has a wide range of purple shades, from dark to light pink. In the centre of the flower stands a cap, with numerous pistils and stamens. The size of the pollen grains is approximately 25 μm and their number can reach two million grains per flower. Each flower produces several hundred seeds, covered by a woolly or glabrous coat (Horovitz et al., 1975; Laura & Allavena, 2007). The species is mostly cross pollinated by insects, including bees, flies and beetles, which are attracted to the flowers to feed or collect pollen (Keasar et al., 2008; Laura & Allavena, 2007).

Geographical distribution of *A. coronaria* encompasses the eastern Mediterranean littoral, from Greece, southern Turkey, Syria, Lebanon and Jordan, to Israel. Also, to a lesser extent, it occurs between northern Iraq to the east, and Italy, southern France and North Africa to the west (Horovitz et al., 1975). Throughout the years, public opinion surveys in Israel have revealed that the species is one of the most familiar, and is also considered a favourite. This has been accredited to the ornamental and aesthetic features of the species.

2.2 | Regional settings

The study region expands across the north-western, semi-arid Negev of Israel (31°35′N, 34°59′E, ~90–100 m.a.s.l.; Figure 1). The region's lithology is calcareous sandstone, landform is composed of plains transected by ephemeral streams (wadis), and soil is loessial Serozem (Calcic Xerosol) with a sandy loam texture. The mean daily temperature is 12°C in January and 26°C in July (Bitan & Rubin, 1991). The mean annual cumulative precipitation is 260 (±30) mm (Israel Meteorological Service website: www.ims.gov.il/IMSENG/All_Tahazit/homepage.htm). Rainfall over the three studied years revealed 8%, 49% and 23% higher precipitation (281, 387 and 319 mm for the rainy seasons of 2013/2014, 2014/2015 and 2015/2016, respectively) than that of the long-term mean annual rainfall.

Native herbaceous vegetation species encompass grasses, forbs and legumes, such as: *Sinapis alba* L., *Chrysanthemum coronarium* L., *Erucaria hispanica* L. Druce, *Centaurea iberica* Trevir. ex Spreng., *Carthamus tenuis* (Boiss. & Blanche) Bornm., *Trigonella arabica* Delile, *Schismus arabicus* Nees, and *Stipa capensis* Thunb. The geophyte species of *A. coronaria* is also prevalent across the region, which encompasses its southern boundary.

2.3 | The study scheme

The study was conducted at the Migda Experimental Farm of the Agricultural Research Organization. The farm has a long-term, grazing exclusion land unit, with a total area of approximately 10 ha, which aims to reconstruct the "natural" environmental conditions. In this land unit, a total of 12 research plots were delineated in 2006. Each plot size, determined by the site's landform characteristics, was set over 24 × 127 m (3,048 m^2). Of these plots, three were designated for early-season (germination stage) grazing, an additional three for mid-season (flowering stage) grazing, and the final three for end-season (ripening stage) grazing. An additional three plots were delineated for long-term grazing exclusion (control treatment). The treatments were delineated in three blocks, each containing one plot per treatment.

The timing of grazing for each year was set according to the beginning of germination, determined by the timing of the earliest precipitation. The number of animals was identical for all of these treatments, composed of one session of 200 sheep (average weight 63.5 ± 4.0 kg/animal) for 1 ha, yielding a stocking rate of 0.12 livestock unit ha^{-1} $year^{-1}$ (composed of 8 hours of grazing a day [0.04 livestock unit ha^{-1} $year^{-1}$] + 16 hours attendance a day [0.08 livestock unit ha^{-1} $year^{-1}$]; see Allen et al., 2011; Coughenour, 1991). In each plot, grazing treatment has been identical every year since 2006, and until 2016.

2.4 | Data gathering and laboratory work

The number of *A. coronaria* flowers was chosen as an indicator for the abundance of vital individuals for this species. The rationale for choosing this method was because (1) it expresses reproductive potential as it reflects sexual propagation; (2) it indicates pollination dynamics, and therefore, also demonstrates ecosystem functioning and health; and (3) the ease involved in its visual monitoring over extended land units, evident by the red colour which is clearly distinct from the

FIGURE 1 Map of Israel marked with the study site.

generally greenish background during the growing season. The number of flowers was visually identified and recorded throughout the growing season (germination to senescence), at a frequency of around every five days (six times a month). This was conducted, in each of the study's 12 plots, for three consecutive years, between 2013/2014 and 2015/2016 (7–9 years, respectively, after the establishment of the plots). The schedule for recording the number of flowers over the growing season was determined by *A. coronaria*'s phenology, which was primarily controlled by the precipitation regime in each of the studied years.

Sampling of (total) aboveground biomass and soil was conducted in summer 2016 – 10 years after the establishment of the treatments plots – to determine the impact of treatment on selected characteristics. Aboveground biomass was assessed by harvesting all the plant material in 0.2 × 0.2 m quadrates at five spots per plot, and drying it in an oven set to 65°C for 48 hours. Soil sampling was conducted at the same spots, and at two depths (0–5 and 5–10 cm) per spot. Therefore, the number of samples (n) for aboveground biomass was 3 blocks × 4 treatments × 5 spots = 60. The number of soil samples was 3 blocks × 4 treatments × 5 spots × 2 depths = 120. From each soil sampling spot and depth, a 100 ml core (5 cm diameter × 5 cm height) and a 300 ml bag of composite soil were obtained.

The soil core samples were analysed for bulk density (Grossman & Reinsch, 2002), saturated hydraulic conductivity, intrinsic permeability (by the constant head method: Reynolds & Elrick, 2002; Shukla & Lal, 2004), and coarse root biomass (Böhm, 1979). The composite soil samples were studied for (hygroscopic) moisture content (by oven drying at 105°C for 24 hours; Gardner, 1965), aggregate stability (by using wet sieving apparatus: Eijkelkamp, The Netherlands), and total organic matter content (by the dry combustion method [Nelson & Sommers, 1996], after fumigation with diluted hydrochloric acid [Harris et al., 2000]). The results were divided by 1.72 in order to calculate the total organic carbon concentration.

2.5 | Statistical analysis

Statistical analysis was conducted with the general linear model procedure of SAS (SAS Institute, 1990). A split-plots type analysis of variance (ANOVA) was conducted with treatment and block as the main plots, and depth as the sub-plot. For the aboveground biomass, factors in the model were treatment (3 *df*), and block within treatment (2 *df*, error term for treatment). For the soil variables, factors in the model were treatment (3 *df*), block within treatment (2 *df*, error term for treatment), depth (1 *df*), and the interaction of treatment × depth (3 *df*). Significant interactions were prone to an additional ANOVA with the SLICE command of the PROC General Linear Model. Separation of means was determined by Tukey's HSD at the .05 level of probability. Pearson correlation coefficients were calculated for the purpose of examining the relations between the studied variables.

3 | RESULTS AND DISCUSSION

3.1 | Grazing impact

Unexpectedly, the obtained results showed that livestock grazing caused a considerable decrease in abundance of *A. coronaria*, negating the study's major hypothesis. Despite not being significantly (p = .0668) affected by treatment, the mean number of flowers in the control plots was 40%–250% greater than that in the grazing plots (Table 1). These results are inconsistent with those reported by Perevolotsky et al. (2011), which showed a positive effect of livestock on the *A. coronaria* (Perevolotsky et al., 2011). At the same time, our results accord with Noy-Meir and Oron (2001), who reported that *A. coronaria* is being consumed, to some extent, by livestock animals. Similarly, Hadar et al. (1999) mentioned that livestock animals can consume geophyte species known to contain chemicals that reduce their palatability.

The inconsistency with Perevolotsky et al. (2011) could be related to the main limiting factor for primary productivity during mid-to-late winter, which is the growing season for *A. coronaria*. While in the Mediterranean region of northern Israel this limiting factor is sunlight (Noy-Meir & Oron, 2001; Perevolotsky et al., 2011), in the drylands of southern Israel, this limiting factor is the soil-water content (Stavi et al., 2016). This suggests that in our study, grazing adversely affected the soil-moisture status, limiting the availability of water for *A. coronaria*.

This suggestion was demonstrated by the effect of treatment on the mean value of the soil bulk density, which was significantly (p < .0001) greater under each of the grazing treatments than that of the control plots. These results support the study's secondary hypothesis and correspond with previous studies that reported an increase in soil compaction following grazing (Pulido et al., 2017), and particularly so on wet soil (Pulido et al., 2016). It seems that grazing during each of the study years, with the slightly to considerably greater precipitation rates than those of the long-term annual rainfall depth, has exacerbated soil compaction due to hoof action. At the same time, this explanation is not consistent with the treatment effect on saturated hydraulic conductivity and intrinsic permeability, which were similar among all treatments (Table 1).

Despite not being significantly (p = .0965) affected by treatment, livestock has considerably decreased the total aboveground biomass, which was 32%–43% smaller under each of the grazing treatments than that of the control plots. Unexpectedly, the coarse root biomass was not affected (p = .4456) by the studied treatments (Table 1).

TABLE 1 Treatment effect on 3-year mean number of *A. coronaria* flowers (in 3,048 m^2 plot), and 1-year mean of aboveground biomass (mg/ha), coarse root biomass (g 100 cm^{-3}), soil bulk density (mg/m^3), saturated hydraulic conductivity (K_s; cm/hr), intrinsic permeability (k; cm^2 10^{-10}), gravimetric moisture content (%), aggregate stability (%), and organic carbon concentration (g/kg)

	p value	Early-season grazing	Mid-season grazing	Late-season grazing	Control
Three-year mean number of *A. coronaria* flowers	.0668	1,887 a (405)	2,344 a (418)	3,596 a (239)	5,009 a (328)
Total aboveground biomass	.0965	3.8 a (0.7)	4.3 a (0.9)	3.6 a (0.6)	6.4 a (1.1)
Coarse root biomass	.4456	0.2 a (0.02)	0.21 a (0.03)	0.23 a (0.04)	0.26 a (0.02)
Bulk density	**.0001**	1.53 a (0.01)	1.51 a (0.01)	1.52 a (0.01)	1.44 b (0.01)
Hydraulic conductivity	.7518	6.8 a (1.2)	5.9 a (1.0)	6.0 a (1.3)	7.2 a (0.7)
Intrinsic permeability	.719	0.65 a (0.12)	0.57 a (0.09)	0.60 a (0.12)	0.71 a (0.07)
Moisture content	**.0035**	5.5 a (0.2)	5.4 a (0.2)	5.3 ab (0.1)	4.9 b (0.1)
Aggregate stability	**.0333**	44.2 b (3.4)	53.3 ab (3.6)	49.9 ab (3.8)	53.5 a (3.7)
Organic carbon	**.0440**	22.7 ab (1.0)	24.3 a (1.2)	23.1 ab (1.1)	21.4 b (1.2)

Bold p value indicates a significant effect. Means within the same row followed by a different letter differ at the .05 probability level according to Tukey's HSD. Numbers within parentheses are standard error of the means.

3.2 | Timing impact

The results of this study show that the timing of grazing has a considerable impact on *A. coronaria*'s number of flowers. The timing effect followed the order of (non-grazing >) late-season grazing > mid-season grazing > early-season grazing (Table 1). Also, compared with the mid- and late-growing season, in 2013/2014 and 2014/2015, grazing in the early growing season retarded the onset of *A. coronaria*'s flowering for 2–3 weeks (Figure 2a,b). At the same time, no such an effect was recorded for the 2015/2016 growing season (Figure 2c).

The number of flowers of *A. coronaria* under the studied grazing treatments in any year is expected to mainly be affected by grazing taking place in the previous year. This is because the consumption of leaves of *A. coronaria* would limit tuber development, reducing its vitality and decreasing its vigour for the next growing season (Zaady et al., 2007). Therefore, the smaller abundance of vital individuals of *A. coronaria* (as indicated by the generally lower number of flowers) under the early-season grazing treatment is attributed to the consumption of – in previous years – young leaves, with the presumable low toxicity soon after germination. Similarly, the medium number of flowers in the mid-season grazing plots could be related to the selective consumption of retarding individuals, which have not yet reached the toxicity stage. Hence, the findings are in accordance with the study's secondary hypothesis. A somewhat similar mechanism was reported for the wooded pasturelands of central Sardinia, where the geophyte species of *Asphodelus microcarpus* was grazed by livestock in the early season, but completely rejected by the grazing animals during flowering (Alias et al., 2010), when it becomes rich in toxic anthraquinones (IUCN, 2005).

Generally, for all the studied vegetation and soil properties, differences among the three grazing treatments were not significant (Table 1). The rather similar values for each of the soil properties of bulk density, saturated hydraulic conductivity and intrinsic permeability among the three grazing treatments suggest that, over the long run, there have been no consistent differences in the soil moisture status between the early-, mid-, and late-growing seasons. This could be due to the generally (despite exceptional years) heterogeneous distribution of precipitation during the rainy season over the long run (Israel Meteorological Service website: www.ims.gov.il/IMSENG/All_Tahazit/homepage.htm).

3.3 | Implications for management of rangelands and nature reserves

Our results revealed that the impact of grazing on soil quality was bidirectional and apparently inconsistent. On the one hand, aggregate stability had 0.3%–17% smaller mean value under the grazing treatments than that under the control plots. On the other hand, the gravimetric moisture content and soil organic carbon concentration had 8%–12% and 6%–13%, respectively, higher mean value under the grazing treatments than that under the control plots (Table 1).

The increase in soil organic carbon concentration following grazing (Table 1) could be attributed to the mixing of organic residues in the soil by the livestock hoof action. This mechanism was proposed by Stavi et al. (2016), who found for the same geographical region that trampling by livestock which graze stubble residues in post-harvest wheat agro-ecosystems has resulted in the increase in soil organic carbon pools. This effect improves the physical quality of soil, which in turn, allows for better hydraulic properties of the ground surface (Stavi et al., 2016). In this present study, this effect was exemplified by the higher gravimetric moisture content under each of the grazing treatments than that under the control plots. Despite not being available for plant uptake, the hygroscopic level's soil-water content during the hot and dry summer still indicates the physical quality of soil and, therefore, its potential for sustaining primary productivity.

Yet, unlike the stubble grazing that took place during the dry summer season, which subsequently does not compact the soil (Stavi et al., 2016), our study deals with grazing in the wet winter season, when soil moisture content is comparatively high. This allows the compaction and deformation of the soil structure, reducing hydraulic conductivity, and lowering the availability of water for plant uptake (Warren et al., 1986). The greater compactability of soil under moist conditions is because as the soil becomes wet, the friction between particles decreases, allowing the particles to slide over each other and easing the deformation of the soil structure (soil compaction in England and Wales, 2008).

The studied soil properties revealed a generally better soil quality at the shallower depth than at the deeper depth. An exception was the effect on volumetric moisture content, which was 14% greater at the 5–10 than at the 0–5 cm depth (Table 2). This effect could be attributed to the high evaporation rates during the hot and dry summer season, with the greater effect at the surface layer than at the subsoil layer (Xiao et al., 2011). The effect of the interaction between treatment and depth was not significant for any of the studied soil properties.

Overall, this study shows that unlike in Mediterranean regions, grazing in the studied dryland site had an overall negative effect on the abundance of *A. coronaria*. It seems that this difference is related to the main limiting factor during the growing season, which is access to sunlight in the Mediterranean regions, and to soil water in drylands. Previous studies

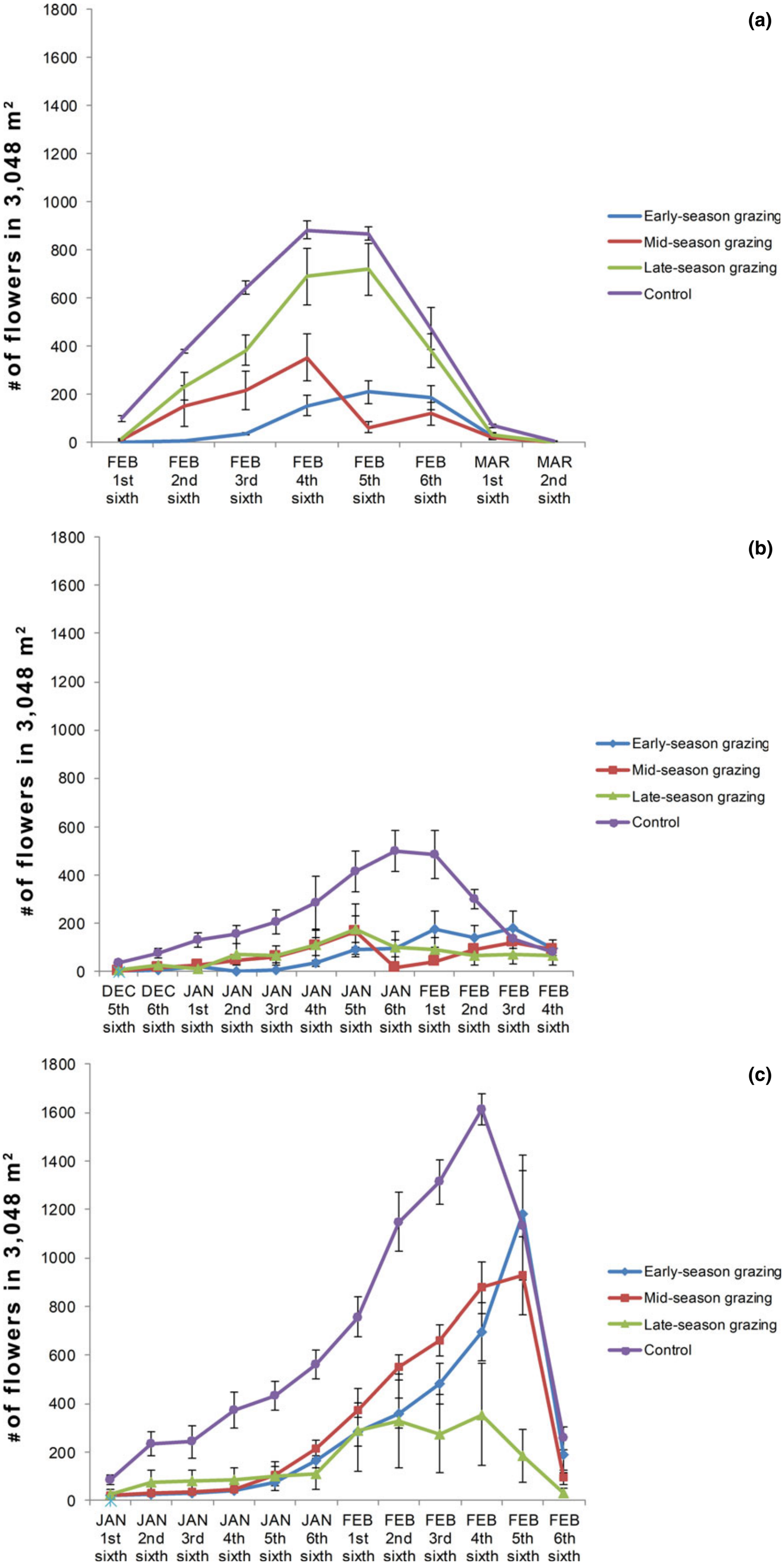

FIGURE 2 (a) The effect of timing of grazing on number of *A. coronaria* flowers during the 2013/2014 growing season. (b) The effect of timing of grazing on number of *A. coronaria* flowers during the 2014/2015 growing season. (c) The effect of timing of grazing on number of *A. coronaria* flowers during the 2015/2016 growing season.

TABLE 2 Soil depth effect on mean coarse root biomass (g 100 cm^{-3}), soil bulk density (mg/m^3), saturated hydraulic conductivity (K_s; cm/hr), intrinsic permeability (*k*: cm^2 10^{-10}), gravimetric moisture content (%), aggregate stability (%), and organic carbon concentration (g/kg)

	p value	0–5 cm	5–10 cm
Coarse root biomass	**.0001**	0.29 a (0.03)	0.15 b (0.01)
Bulk density	**.0137**	1.49 b (0.01)	1.51 a (0.01)
Hydraulic conductivity	**.0001**	8.4 a (0.9)	4.5 b (0.4)
Intrinsic permeability	**.0001**	0.82 a (0.09)	0.44 b (0.03)
Moisture content	**.0001**	4.9 b (0.1)	5.6 a (0.1)
Aggregate stability	**.0001**	64.7 a (2.0)	35.7 b (1.5)
Organic carbon	**.0001**	27.0 a (0.7)	18.8 b (0.3)

Bold *p* value indicates a significant effect. Means within the same row followed by a different letter differ at the .05 probability level according to Tukey's HSD. Numbers within parentheses are standard error of the means.

suggested that the regulation of access to sunlight in the Mediterranean regions is mainly due to the consumption of other herbaceous vegetation species, supporting the competitive capacity of *A. coronaria*. At the same time, our study suggests that the regulation of access to soil water in drylands, which pertains to soil compaction by the livestock's hoof action, suppresses the growth of this geophyte species.

Additionally, this study proposes that the abundance of *A. coronaria* is directly regulated through its consumption by the livestock animals. Therefore, in terms of fulfilling nature conservation goals, it is suggested that the timing of grazing could be used as a management tool for controlling the consumption of this species. This goal could be accomplished if livestock access would be negated in the early growing season, when digestion inhibitors have not yet developed in *A. coronaria*'s shoots. Also, to prevent extreme soil compaction by hoof action, it is proposed that livestock access should be negated shortly after rainstorms. Regardless, future studies should monitor livestock behaviour, specifically observing the grazing habits of livestock animals throughout the growing season.

4 | CONCLUSIONS

Unlike in Mediterranean regions, where abundance of *A. coronaria* was reported to increase following animal grazing, we found that in the southern Israeli drylands, this abundance was negatively affected by livestock. We explained this effect by the combination of two mechanisms. The first is the consumption of *A. coronaria* in the early growing season, or soon after germination, when the non-palatable chemical content in its shoots is still low. The second is trampling on the wet soil during winter, which compacts the soil, reducing hydraulic conductivity, and lowering water availability for vegetation uptake. As a management tool for nature conservation, we propose that livestock grazing should be negated in *A. coronaria*'s early growing season, as well as shortly after rain showers.

ACKNOWLEDGEMENTS

The authors are grateful to Asaf Shifman for providing thorough background information on morphology, phenology, propagation and distribution of *A. coronaria*. The study was funded by the Yad Hanadiv Foundation. The authors are grateful to three anonymous reviewers, whose comments allowed the considerable improvement of the manuscript.

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How to cite this article: Stavi I, Shuker S, Barkai D, Knoll YM, Zaady E. Effects of livestock grazing on *Anemone coronaria* L. in drylands: Implications for nature conservation. *Geo: Geography and Environment*. 2018;e53. https://doi.org/10.1002/geo2.53