Catena 114 (2014) 149–156

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Latitude, basin size, and microhabitat effects on the viability of Acacia trees in the Negev and Arava, Israel

I. Stavi [a,*], M. Silver [b], Y. Avni [c]

[a] Dead-Sea & Arava Science Center, Ketura 88840, Israel
[b] Arava Drainage Authority, Sapir 86825, Israel
[c] Geological Survey of Israel, Jerusalem 95501, Israel

ARTICLE INFO

Article history:
Received 17 January 2013
Received in revised form 10 October 2013
Accepted 16 October 2013

Keywords:
Climatic change
Flood events
Geological and hydrological background
Long-term precipitation regimes
Rainfall events
Water stress

ABSTRACT

In the hyper-arid Arava Valley and eastern Negev desert of Israel, the acacia species of *raddiana*, *tortilis*, and *pachyceras* play a central role as keystone species. Many studies implemented during the last few decades have revealed considerable changes in acacia populations, including high mortality rates and low recruitment. The objective of this study aimed to examine the relationships between presumed water availability for acacia populations and their mortality by examining the effect on tree mortality of latitude, basin size, and microhabitat in the valley floor. A total of 1980 acacia trees in 11 wadis along the Arava and eastern Negev region were studied. The obtained results revealed a highly varied inter-wadi mortality rate, ranging between 6.7% and 72.2%. Overall, mortality within species occurred in 14.7% of *Acacia pachyceras*, 16.8% of *Acacia tortilis*, and 29.4% of *Acacia raddiana*. A highly negative correlation coefficient ($r = -0.55$; $P < 0.0001$) was found between latitude and acacia mortality. However, a low and not statistically significant correlation coefficient was found between basin size and acacia mortality ($r = -0.24$; $P = 0.2103$). In terms of overall occurrence in microhabitat across the valley floor, 6.4% of the trees were located in main channels, 9.8% in high banks, 10.4% in bars, 19.1% in secondary channels, and 54.3% in low banks. However, the effect of microhabitat on acacia mortality rates was not statistically significant ($P = 0.2240$). In addition to these, we monitored the occurrence of the hemiparasite, mistletoe (*Plicosepalus acaciae*), which was observed in 8.2% of the trees. Also, the tree canopies' height and diameter were measured in order to calculate a size index for them. Values of this index were divided into four groups in order to represent the size distribution of trees. The overall occurrence of 3.6% of the smallest tree-size group is worrisome, as it presumably indicates very low recruitment rates.

1. Introduction

Acacia trees are one of the main keystone species in the Middle Eastern and African drylands. As in other desert regions, these trees are prevalent in the arid and hyper-arid regions of southern Israel. Specifically, they can be found in the wadis of the Arava Valley and eastern Negev desert (Ben David-Novak and Schick, 1997; Sher et al., 2010). The acacia genus in the Israeli drylands consists of three species: *raddiana* (Savi), *tortilis* (Forssk.), and *pachyceras* (*O. Schwartz*; formerly *gerrardii* [*Benth.*]/*negevensis* [*Zohary*]). Of these species, the *Acacia raddiana* and *Acacia tortilis* are specifically characterized as resistant to high temperatures, to erratic precipitation regimes, and to extreme droughts, making these species prevalent in hyper-arid regions (Hammouda et al., 2005). At the same time, the *A. pachyceras* is more resistant to colder temperatures (see: *Acacia gerrardii* Grey-haired acacia), enabling its widespread occurrence in the milder parts of the Negev desert and Arava Valley. Worrisome observations of high mortality rates and low recruitment rates of acacias in this region have led to the implementation of many studies aimed at exploring the causes and implications of these trends. In this regard, it is important to mention that, as with many other tropical and sub-tropical species, the main challenge in monitoring the life-cycle of acacias under field conditions stems from the absence of yearly tree-rings, which prevents the determination of the age of individuals (see: Wiegand et al., 2000). Further, this feature limits the possibility of relating the mortality of individual trees to "natural" phenological cycles on the one hand, or to "disturbances" such as extreme climatic change, on the other.

The earliest comprehensive survey of the status of acacia populations in southern Israel was implemented by Ashkenazi (1995), who reported alarming demographic changes. Several causes were suggested for these changes. The most prominent, and perhaps obvious factor proposed to cause these trends is the reduction in water availability for trees (Shrestha et al., 2003; Wiegand et al., 2004). Climatic changes seem to have had a crucial impact on Israeli inlands, where precipitation regimes have shrunk dramatically, and temperatures have increased tremendously, resulting in an elevated regional aridity index since the 1970s (Kafle and Bruins, 2009). The smaller precipitation events have decreased rates and magnitudes of flood events, resulting in smaller quantities of water to valley floors (Shlomi and Ginat, 2009). Other

* Corresponding author. Tel.: +972 8 635 6547; fax: +972 8 635 6634.
E-mail address: istavi@yahoo.com (I. Stavi).

0341-8162/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.catena.2013.10.006

studies suggested that water availability has shrunk due to anthropogenic disturbances such as the drilling of underground water that has extracted moisture from relatively shallow horizons, roads that transect valley floors, and soil mining and infrastructure works that have modified the wadis' water courses (Ben David-Novak and Schick, 1997; Ward and Rohner, 1997). Other studied mechanisms inducing modifications in acacia populations have included competition with *Tamarix* plants for water (Sher et al., 2010), decreased populations of large mammalian herbivores (Or and Ward, 2003; Ward and Rohner, 1997), infestation of the hemiparasitic mistletoe (*Plicosepalus acaciae* [Zucc.], formerly *Loranthus acaciae*) plants (Wiegand et al, 2000), and infestation of insects that attack the acacia's seeds (Or and Ward, 2003). Despite a general consensus regarding the adverse modifications affecting southern Israel's acacia populations, a study by Lahav-Ginott et al. (2001) reported that a certain area in the central Arava – Wadi Yoash and Wadi Saif, about 20 km south of the Dead Sea – displayed no signs of viability decrease, but rather experienced an increase in viability during the second half of the 20th century.

A brief survey conducted by the authors during the second half of 2010, revealed highly varied mortality rates of acacias in several wadis of the Arava and eastern Negev. Therefore, in order to better understand the prevailing dynamics in the acacias' demography, we decided to comprehensively study the viability of acacia trees throughout this region. Specifically, we focused on the relationships between mortality rates of acacias and presumed availability of water. The study had three hypotheses proposing that mortality rates are greater (1) in the more southern wadis. This hypothesis was based on knowledge of the decreasing precipitation regimes from north to south along the study

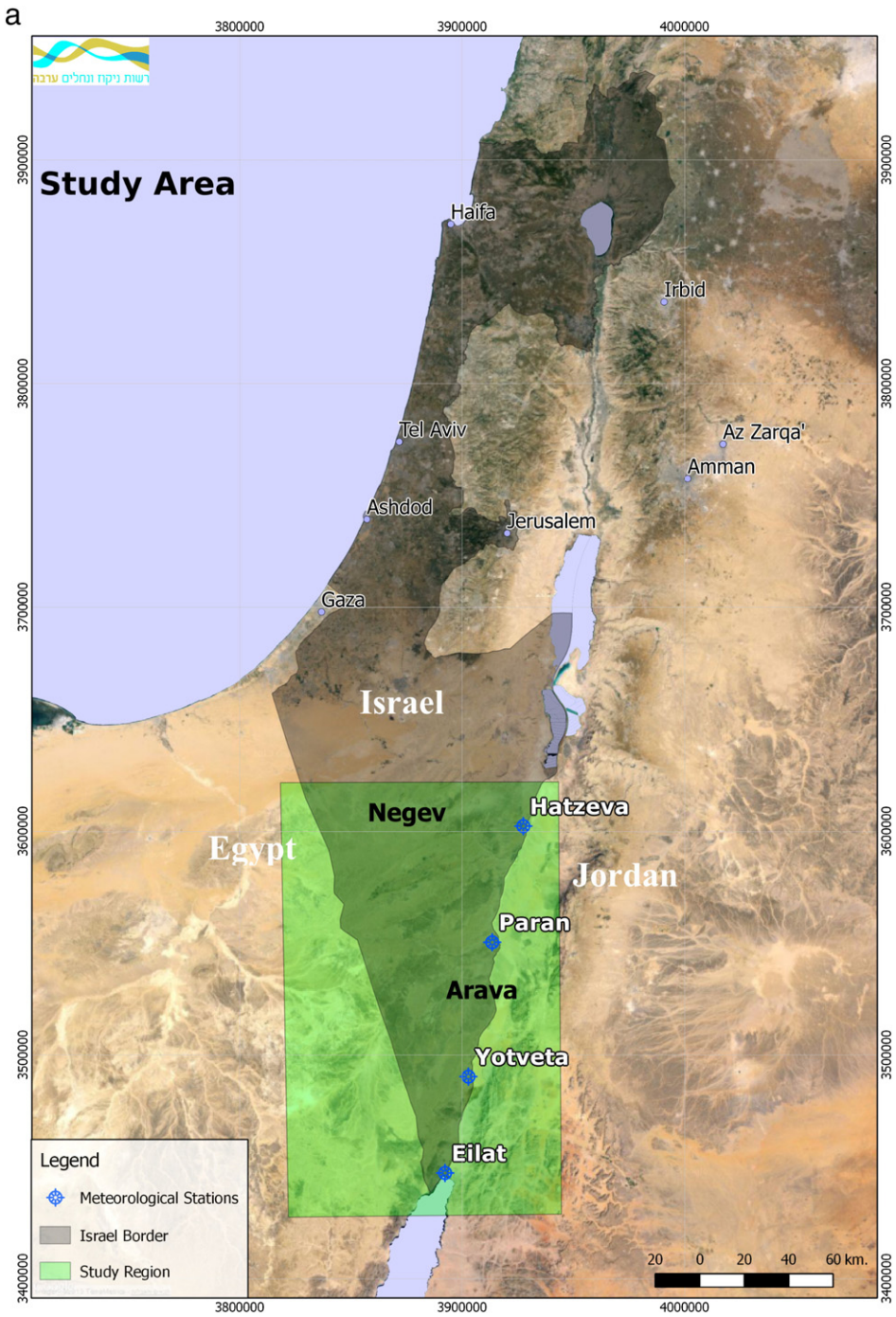

Fig. 1. a. Map of Israel. b. Map of the study region.