The Archaeology of Seasonality

STUDIES IN CLASSICAL ARCHAEOLOGY

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The Archaeology of Seasonality

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List of Abbreviations

Ach. Tat.	Achilles Tatius
AE	*L'année épigraphique*
Aesch., *Supp.*	Aeschylus, *Supplices*
Alci.	Alciphron
Alci., *Epist.*	Alciphron, *Epistulae*
Alcm.	Alcman
Alex. Aphr.	Alexander of Aphrodisias
Amm. Marc.	Ammianus Marcellinus
Anth. Pal.	*Anthologia Palatina*
Antiph.	Antiphon
Apollod.	Apollodorus, *Library*
App., *B. Civ.*	Appian, *Bella civilia*
Aristoph., *Ach.*	Aristophanes, *Acharnenses*
Aristoph., *Av.*	Aristophanes, *Aves*
Aristoph., *Nub.*	Aristophanes, *Nubes*
Aristoph., *Pax*	Aristophanes, *Pax*
Aristot., *Ath. pol.*	Aristotle, *Athenaion Politeia*
Aristot., *Hist. an.*	Aristotle, *Historia animalium*
Aristot., *Pr.*	Aristotle, *Problemata*
Ath.	Athenaeus
Aug., *Civ.*	Augustinus, *De civitate Dei*
BGU	Königliche Museen zu Berlin. 1892. *Aegyptische Urkunden aus den Königlichen Museen zu Berlin*, Griechische Urkunden (Berlin: Weidmann).
Caes., *B Gall.*	Caesar, *De bello Gallico*
Callim., *H.*	Callimachus, *Hymni*
Calp., *Ecl.*	Calpurnius Siculus, *Eclogae*
Cass. Dio	Cassius Dio
Cato, *Agr.*	Cato, *De agri cultura*
Celsus, *Med.*	Cornelius Celsus, *De medicina*
Cic., *Ad Q. Fr.*	Cicero, *Epistulae ad Quintum fratrem*
Cic., *Att.*	Cicero, *Epistulae ad Atticum*
Cic., *Cat.*	Cicero, *In Catilinam*
Cic., *De or.*	Cicero, *De oratore*
Cic., *Off.*	Cicero, *De officiis*
Cic., *Phil.*	Cicero, *In M. Antonium orationes Philippicae*
Cic., *Mil.*	Cicero, *Pro T. Annio Milone*
Cic., *Nat. D.*	Cicero, *De natura deorum*
Cic., *Sest.*	Cicero, *Pro P. Sestio*
CIL	*Corpus inscriptionum latinarum*
Cod. Theod.	*Codex Theodosianus*
Colum.	Columella
Cypr.	Cyprianus
Dem., *Or.*	Demosthenes, *Orationes*
Diod. Sic.	Diodorus Siculus
Diog. Laert.	Diogenes Laertius
Dion. Chrys.	Dion Chrysostomus
Eur., *Alc.*	Euripides, *Alcestis*
Eur., *Supp.*	Euripides, *Supplices*
Euseb., *On.*	Eusebius, *Onomasticon*
FGrH	Jacoby, F. 1923–. *Die Fragmente der griechischen Historiker* (Berlin: Weidmann; Leiden: Brill)
Frontin., *Aq.*	Frontinus, *De aquae ductu urbis Romae*
Gal.	Galenus
Gell., *NA*	Gellius, *Noctes Atticae*
GHI	Osbourne, R. and P. J. Rhodes (eds). 2017. *Greek Historical Inscriptions 478–04 BC* (Oxford: Oxford University Press).
Gp.	Geoponica
Greg. Tur.	Gregorius of Tours
H. Hom.	*Hymni Homerici*
Hdt.	Herodotus
Hes.	Hesiod
Hes., *Op.*	Hesiod, *Opera et dies*
Hes., *Theog.*	Hesiod, *Theogonia*
Hippoc.	Hippocrates
Hom., *Il.*	Homerus, *Ilias*
Hom., *Od.*	Homerus, *Odyssea*
Hor. Ars P.	Horatius
Hor. Ars P., *Carm.*	Horatius, *Carmina*
Hor. Ars P., *Epist.*	Horatius, *Epistulae*
Hor. Ars P., *Sat.*	Horatius, *Satirae (sermones)*

Hyg., *Fab.*	Hyginus, *Fabulae*
I. Eleusis	Clinton, K. 2005–08. *Eleusis: The Inscriptions on Stone; Documents of the Sanctuary of the Two Goddesses and Public Documents of the Deme* (Athens: The Archaeological Society at Athens).
I.Gerasa	Welles, C. B. 1938. 'The Inscriptions', in C. H. Kraeling (ed.), *Gerasa: City of the Decapolis* (New Haven: American Schools of Oriental Research), pp. 353–494.
IG	Inscriptiones Graecae
ILAfr	Cagnat, R., A. Merlin, and L. Chatelain (eds). 1998. *Inscriptions latines d'Afrique (Tripolitaine, Tunisie, Maroc)* (Pamplona: Microfilmaciones Pamplona).
ILAlg.	Gsell, S. and others (eds). 1922. *Inscriptions latines de l'Algérie* (Paris: Champion).
ILS	Dessau, Hermann. 1892–1916. *Inscriptiones latinae selectae*, 3 vols (Berlin: Weidmann).
IRT	Reynolds, J. M. and J. B. Ward-Perkins (eds). 1952. *Inscriptions of Roman Tripolitania* (Rome: British School at Rome).
Is.	Isocrates
Jos., *Ant. Iud.*	Josephus, *Antiquitates Iudaicae*
Jos., *BI*	Josephus, *Bellum Iudaicum*
Julian.	Julianus
Juv.	Juvenalis, *Saturae*
Lib., *Or.*	Libanius, *Orationes*
LIMC	*Lexicon iconographicum mythologiae classicae*
Liv.	Livius, *Ab urbe condita*
Lucian.	Lucianus
Lucian., *Anach*.	Lucianus, *Anacharsis*
Lucian., *Dial. meret.*	Lucianus, *Dialogi meretricium*
Lucr.	Lucretius, *De rerum natura*
Mart.	Martialis
OLD	Glare, P. G. W. and C. Stray. 2012. *Oxford English Dictionary*, 2nd edn (Oxford: Oxford University Press).
Opp., *Hal.*	Oppianus, *Halieutica*
Orph., *H.*	Orpheus, *Hymni*
Ov., *Am*.	Ovidius, *Amores*
Ov., *Ars am*.	Ovidius, *Ars amatoria*
Ov., *Fast.*	Ovidius, *Fasti*
Ov., *Met*.	Ovidius, *Metamorphoses*
Ov., *Pont*.	Ovidius, *Epistulae ex Ponto*
Ov., *Rem. am*.	Ovidius, *Remedia amoris*
Ov., *Tr.*	Ovidius, *Tristia*
P Col. Zen.	Westermann, W. L. and E. S. Hasenoehrl (eds). 1934. *Columbia Papyri*, III: *Zenon Papyri: Business Papers of the Third Century B.C. Dealing with Palestine and Egypt* (New York: Columbia University Press).
P CTYBR	Yale Papyrus Collection
P CZ	Edgar, C. C. (ed.). 1925–31. *Zenon Papyri: Catalogue général des antiquités égyptiennes du Musée du Caire*, 4 vols (Cairo: Institut français d'archéologie orientale).
P Fay.	Grenfell, B. P., A. S. Hunt, and D. G. Hogarth (eds). 1900. *Fayum Towns and their Papyri* (London: Egypt Exploration Fund).
P Mich.	*Michigan Papyri*
P Mich Inv.	*Michigan Papyri Inventory*
P Mil.	Daris, S. (ed.). 1967. *Papiri Milanesi*, I, fasc. I, 2nd edn (Milan: Società editrice Vita e pensiero).
P Oxy.	Grenfell, B. P. and others (eds). 1989–. *The Oxyrhynchus Papyri* (London: Egypt Exploration Fund).
P Ryl. Copt.	Crum, W. E. (ed.). 1909. *Catalogue of the Coptic Manuscripts in the Collection of the John Rylands Library* (Manchester: Manchester University Press).
P Yale	Montserrat, D. and others (eds). 1994. 'Varia Descripta Oxyrhynchita'. *Bulletin of the American Society of Papyrologists*, 31: 11–80.
Pall.	Palladius
Pall., *Agric.*	Palladius, *Opus agriculturae*
Pan. Lat.	Panegyrici Latini
Paus.	Pausanias
Pers.	Persius, *Saturae*
Petron, *Sat.*	Petronius, *Satyrica* (Müller 1961)

Philostr., *VS*	Philostratus, *Vitae sophistarum*
Philostr., *Imag.*	Philostratus, *Imagines*
Pind., *Fr.*	Pindar, *Fragments* (Snell/Maehler)
Pind., *Ol.*	Pindar, *Olympian Odes*
Pind., *Nem.*	Pindar, *Nemean Odes*
Pind., *Pae.*	Pindar, *Paeanes*
Pl.	Plato
Pl., *Leg*.	Plato, *Leges*
Pl., *Resp*.	Plato, *Res publica*
Pl., *Symp*.	Plato, *Symposium*
Pl., *Ti*.	Plato, *Timaeus*
Plaut., *Epid*.	Plautus, *Epidicus*
Plaut., *Mil.*	Plautus, *Miles gloriosus*
Plaut., *Mostell.*	Plautus, *Mostellaria*
Plaut., *Rud*.	Plautus, *Rudens*
Plin., *Ep*.	Plinius minor, *Epistulae*
Plin., *HN*	Plinius maior, *Naturalis historia*
PLRE	Jones, A. H. M. and others. 1970. *Prosopography of the Later Roman Empire* (Cambridge: Cambridge University Press); 2nd and 3rd edn: John Robert Martindale, 1980–92.
Plut.	Plutarchus
Plut., *Mor.*	Plutarchus, *Moralia*
Plut., Otho	Plutarchus, *Vitae parallelae*, Otho
Pol.	Polybius
Prop.	Propertius, *Elegiae*
Quint., *Inst.*	Quintilianus, *Institutio oratoria*
RE	Pauly, A. and others. 1893–1980. *Pauly's Real-Encyclopädie der classischen Altertumswissenschaft* (Stuttgart: Metzler).
Sen., *Apocal*.	Seneca minor, *Divi Claudii apocolocyntosis*
Sen., *Ben*.	Seneca minor, *De beneficiis*
Sen., *Ep*.	Seneca minor, *Epistulae morales ad Lucilium*
Sen., *Q Nat*.	Seneca minor, *Naturales quaestiones*
SHA, *Alex. Sev.*	Scriptores historiae Augustae, *Alexander Severus*
SHA, *Aur.*	Scriptores historiae Augustae, *M. Aurelius*
SHA, *Carac.*	Scriptores historiae Augustae, *Antoninus Caracalla*
SHA, *Comm.*	Scriptores historiae Augustae, *Commodus*
SHA, *Gord.*	Scriptores historiae Augustae, *Gordiani tres*
SHA, *Hadr.*	Scriptores historiae Augustae, *Hadrianus*
SHA, *Tyr. Trig.*	Scriptores historiae Augustae, *Triginta Tyranni*
Sid. Apoll., *Epist.*	Apollinaris Sidonius, *Epistulae*
*SIG*2	Dittenberger, W. (ed.). 1898–1901. *Sylloge inscriptionum Graecarum*, 2nd edn (Leipzig: Hirzel).
Sil., *Pun*.	Silius Italicus, *Punica*
Simon.	Simonides
Soph., *OT*	Sophocles, *Oedipus Tyrannu*
Stat., *Silv.*	Statius, *Silvae*
Str.	Strabo
Suet.	Suetonius
Suet., *Aug.*	Suetonius, *Divus Augustus*
Suet., *Dom*.	Suetonius, *Domitianus*
Suet., *Vesp*.	Suetonius, *Divus Vespasianus*
Tac., *Dial*.	Tacitus, *Dialogus de oratoribus*
Tac., *Hist*.	Tacitus, *Historiae*
TAM	*Tituli Asiae Minoris*
Tert.	Tertullianus
Theoc.	Theocritus
Theophr., *Hist. pl.*	Theophrastus, *Historia platarum*
ThLL	*Thesaurus linguae latinae*
Tib.	Tibullus, *Elegiae*
Val. Max.	Valerius Maximus, *Facta et dicta memorabilia*
Varro, *Rust.*	Varro, *Res rusticae*
Varro, *Ling.*	Varro, *De lingua latina*
Varro, *Rust.*	Varro, *Res rusticae*
Veg., *Mil.*	Vegetius, *Epitoma rei militaris*
Verg., *G.*	Vergilius, *Georgica*
Vitr., *De arch.*	Vitruvius, *De architectura*
Xen.	Xenophon
Xen., *Cyr*.	Xenophon, *Cyropaedia*
Xen., *Hell*.	Xenophon, *Hellenica*
Xen., *Mem*.	Xenophon, *Memorabilia*
Xen., *Oec*.	Xenophon, *Oeconomicus*

7. Flowers and Faeces: Seasonal Signals from Shivta's Early Islamic Rubbish Middens

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Resolutions of Reconstruction

John sighed. It had been another hot and hard-working July day in the dry desert village of Shivta. The last of the wheat harvest had just been brought in for threshing and the sight of fully formed grapes in the vineyards made John salivate. By the time the grape harvest and wine-making were over, it would be time to prepare for the winter flash floods. There would be repairing check dams damaged in last winter's flash floods, furrowing the wadi soil to improve water absorption when this winter's flash floods arrived, and clearing out bird droppings from the dovecotes to fertilize the vineyards. If there was still time before sowing and the coming of winter rains, there were houses to repair and build. John recalled the verse the monk from the hilltop had taught: 'Your threshing shall overtake the vintage, and your vintage shall overtake the sowing […]'.

* * *

This imaginary description of an ancient farmer's musings reflects part of what we know about the annual agricultural cycle in the Negev Highlands of Late Antiquity. Based on a combination of historical, archaeological, and ethnographic evidence, our current understanding of this ingenious ancient agricultural system in the desert still has a long way to go. The Byzantine Negev Bio-Archaeology (hereafter NEGEVBYZ) project, which focuses on rubbish middens from the Byzantine–Early Islamic periods, has contributed significantly to that understanding. One ultimate research goal is to be able to accurately reconstruct what a day, year, and decade in the life of an ancient Negev farmer might have looked like. This is becoming possible in no small part thanks to rich organic remains retrieved from the rubbish heaps of archaeological sites in the Negev Highlands as part of the NEGEVBYZ project.[1] These illuminate local daily life, economy, and environment, at three main levels of temporality: the synchronic, the diachronic, and the cyclical.

At the synchronic level, analogous in this context to a still-life picture of the local agricultural landscape, plant remains from the combined midden contexts inform us about the food basket of Byzantine–Early Islamic Negev residents. The main components included cereals, pulses, grapes, and a variety of other fruits and nuts, supplemented by fish and sheep/goat products.[2] The essential plant components of this food basket were stable throughout Antiquity in the Negev Highlands, with remains of barley, wheat, grapes, lentils, bitter vetch, figs, olives, and dates present in every excavated midden of the Byzantine–Early Islamic periods. Although this set of cultivars is constant over Late Antiquity, additions to this crop basket are evident over the long term.[3]

At the diachronic level, analogous to a time-lapse motion picture, we can track those economic trends which go beyond basic subsistence. Here we portray the progression of a process over time, on decadal and centennial scales. For instance, using quantitative data on

1 Fuks and others 2016; Tepper and others 2018; Bar-Oz and others 2019; Butler and others 2020; Fuks and others 2020; Langgut and others 2020.

2 Fuks and others 2016; (forthcoming); Marom and others 2019.

3 Fuks and others (forthcoming).

grape pip and cereal grain ratios, we demonstrated a rise and fall in the intensity of Negev Highland viticulture. Through a comparison with ratios of ceramic amphora types, this trend was linked to Mediterranean trade.[4]

Finally, identifications of seasonal cycles represent the most in-depth level of reconstruction and are analogous to a detailed documentary. They provide an opportunity to zoom in on a particular phenomenon, such as seasonal grazing patterns or harvesting seasons. In long-term agricultural history, seasonal cycles are more regular than even the basket of crop plants grown. Since the beginnings of agriculture in the Levant, cereals were sown in winter and harvested in late spring–early summer; grapes were harvested in summer–early autumn; and olives were harvested in late autumn–early winter. These agricultural seasons still hold good today. Moreover, some of the defining features of plant domestication, such as uniformity of ripening and non-shattering of cereal spikelets, concern farmers' ability to reap most of a plant's fruit within a short ripening season.[5] Nevertheless, changes in agricultural seasonality do occur, including crop-plant ripening periods.[6] In addition, historical changes in crop rotation schemes have influenced the basket of summer/winter crops and ultimately the entire social and economic system.[7] Thus, not only are the different levels of temporality related, but combining them yields a more complete historical reconstruction.[8]

The above three-tiered approach to temporal resolution offers a convenient model for historical reconstructions based on archaeobotanical and archaeological evidence from the Late Antique Negev Highlands. In this, it is similar to Braudel's triple categories of environmental history (*la longue durée*), social history (*conjuncture*), and the history of events (*événementielle*),[9] and to his distinction between material life and economic life.[10] Seasonal rhythms of daily life belong to Braudel's category of material life, rather than economic life, but it is not clear whether they are comparable to *événementielle* or *la longue durée*. Although the seasons are ephemeral like the history of events, the regularity of seasonal cycles makes them the most stable and unchanging of the three.

Unfortunately, many archaeological investigations fail to go beyond a synchronic snapshot of the contexts excavated, let alone attain seasonal reconstructions. Tracking changes over time — whether between periods or seasons — often requires a combination of excavation luck and methodological preparation. Yet by focusing on the latter it is possible to prepare for serendipity, as the saying goes: 'When luck joins the game, cleverness scores double'. In this spirit, we present finds from Shivta's Early Islamic rubbish middens — some lucky finds and some more standard ones — which convey information on seasonality. These middens were formed through rapid deposition of burned household waste and contain high concentrations of well-preserved plant matter.[11] Our focus is on the method and theory of seasonal reconstruction from plant remains in the hope that an awareness of these seasonal indicators' potential and pitfalls will be useful for other researchers.

Seasonality in Archaeology

Efforts to reconstruct seasonal patterns in archaeology are not new. Seasonal occupation of Epipaleolithic hunter-gatherer sites, for instance, has received extensive attention in the literature.[12] Such efforts are rarer in the archaeology of later periods, which is dominated by the study of fully sedentary agricultural societies. Yet, seasonal cycles were just as pervasive in ancient agricultural society. In the Levant, everything from religious ritual to work routines revolved around the time for sowing and the time for reaping, the anticipation of rain, and the height of grass in steppe rangelands.

Much of what we know about ancient seasonal cycles over the past few millennia comes from textual sources. For instance, the biblical festivals of Passover and Pentecost mark the barley and wheat reaping times, respectively, while Tabernacles represents the ingathering of the harvest (Exodus 23.14–17; Leviticus 23; Deuteronomy 16). The ultimate biblical blessing is when

4 Fuks and others 2020.

5 Zohary, Hopf, and Weiss 2012.

6 Genetic changes in ripening season are also part of crop evolution and dispersal, enabling, for instance, wheat and barley to be introduced to northern latitudes and higher altitudes (see e.g. Jones and others 2008; Fuller and Allaby 2009; Lister and others 2009; Spengler 2019a).

7 See e.g. Le Roy Ladurie 1976, 45–47; Watson 1983.

8 Braudel 1972.

9 Braudel 1972, 20–21; 2009.

10 Braudel 1973, xii.

11 Tepper and others 2018; Dunseth and others 2019; Butler and others 2020.

12 Kislev, Nadel, and Carmi 1992; Lieberman 1993; Simmons and Nadel 1998; Martin, Edwards, and Garrard 2010; Jones 2012; Snir and others 2015; Henton and others 2017.

seasonal agricultural chores overlap (Leviticus 26.5; Amos 9.13). Meanwhile, the Gezer Calendar provides a relatively detailed extra-biblical record of seasonal agricultural chores.[13] In later periods, textual sources continue to reflect the pervasiveness of seasonality in daily agricultural life.[14] Perhaps even more than historical texts, numerous ethnographic studies of the last hundred years or so inform our understanding of seasonality in traditional and ancient society, while also contributing to the interpretation of ancient texts.[15]

In order to further advance our understanding of ancient seasonal cycles, archaeology — especially of historical periods — needs to catch up with philology and ethnography. Only then can we study the relationship between what is reported and what is left behind as regards seasonality. Comparisons between the description of specific seasonal activities and their archaeological signatures will yield a variety of new insights, taking the reconstruction of ancient daily life to new levels. Moreover, just as paleoclimatic studies of the last two thousand years can attain much higher resolution than of earlier periods due to the quality of the proxy data and, for recent centuries, the addition of written records,[16] so too can the archaeology of seasonality attain higher resolution in historical periods than in pre-recorded history.

Seasonality in Archaeobotany

Among the most powerful archaeological proxies for detecting seasonal aspects of economy and environment are ancient plant remains. These may include tree rings, pollen, or macroscopic plant parts such as flowers, seeds, and fruits.

Tree rings enable the highest-precision dating in archaeology, giving rise to the field of dendrochronology, and tree ring analysis can also be a source of seasonal ecological information.[17] For instance, dendroecology was instrumental in proving that the winter of AD 536 and the decade thereafter were particularly cold and dry in Europe.[18] However, traditional dendrochronological methods cannot go beyond annual resolution to sub-annual seasonal reconstruction. Furthermore, in the semi-arid and arid regions of the Levant, specimens useful for dendroecology (whether living trees or archaeological wood) are very rare.

Pollen, by its nature, is season-specific and can be used to determine, for instance, the season in which wall-plaster was set.[19] However, pollen identification often cannot go beyond the taxonomic level of genus, and different species of the same genus may have opposite flowering times. For instance, only three species of *Artemisia* are native to the Negev, of which the two more common species flower in autumn–winter. Yet the fact that one of the three flowers in spring–summer limits the value of *Artemisia* pollen as a seasonal indicator.[20]

Plant seeds and fruits often preserve under different conditions than pollen — primarily by carbonization — thus complementing seasonal information from pollen. Moreover, seeds can usually be identified to species, which is crucial for achieving high-resolution seasonality data. Species-specific flowering and fruiting times enable macroscopic plant remains to be a proxy for sub-annual seasonal identification, under the right circumstances. One precedent for the use of plant macro-remains in reconstructing seasonality is Kislev's study of the Abi'or Cave assemblage near Jericho, used as a hideout by Bar Kokhba rebels in AD 135.[21] Kislev used the overlap in tree-fruit ripening seasons to indicate the period of the rebels' temporary inhabitation of the cave, on the assumption that these fruits are more frequent just after their ripening season. Of ten tree-fruit species identified, nine may be harvested ripe in September, leading to the conclusion that the rebels occupied the cave in September or October. This type of analysis represents one of three different approaches to seasonality discussed below, namely, flowering and fruiting season convergence in a plant assemblage. The other two are delicate plant parts such as flowers, and seeds within dung pellets.

Seasonality in Shivta's Early Islamic Rubbish Middens

The Early Islamic (Umayyad)-period rubbish middens of Shivta are, like most archaeological middens of the Negev Highlands, immensely rich in organic waste, including charred seeds and other plant macro-

13 Borowski 2002, 31–38; Dalman 2013, 6–8 and references.

14 Feliks 1990; Decker 2009.

15 Dalman 2013; Safrai 1994.

16 Luterbacher and others 2012; McCormick 2013; 2019; Haldon and others 2018.

17 Manning and Bruce (eds) 2009.

18 Büntgen and others 2011; 2016; 2020.

19 Langgut and others 2013, table 1.

20 Dunseth and others 2019; Fuks and Dunseth 2021.

21 Kislev 1992.

Figure 7.1. Southern Shivta during the 2016 excavations (© Daniel Fuks).

Figure 7.2. Early Islamic (Umayyad) rubbish middens in domestic quarters of southern Shivta: Area K (left) and Area E (right) (© Daniel Fuks; Yotam Tepper).

remains (Figs 7.1–7.2).[22] Unlike other Negev Highland trash mounds, these were deposited inside abandoned domestic quarters, contain only small quantities of pottery, and appear to represent a rapid accumulation of household waste. They include three middens, Area E (2.0 m × 4.5 m) and the adjacent Areas K1 (1.5 m × 4.0 m) and K2 (1.5 m × 3.0 m).[23]

The preservation and variety of plant remains in Early Islamic Shivta's excavated middens are exceptional, as exemplified by many delicate plant parts. Several whole sheep/goat dung pellets were also retrieved from these middens, some of which contained identifiable plant remains.[24] The presence of delicate plant remains and dung pellets also indicated the possibility of attaining seasonal information. For both to survive intact, it

22 Fuks and others 2016; Tepper and others 2018.

23 Tepper and others 2018, table 1.

24 Dunseth and others 2019; Fuks and Dunseth 2021.

is likely that they would have been deposited relatively close to their time of production (see below). Further, due to the nature of each, it is possible to identify the season of their production using a botany-informed analysis. In what follows, we employ information on flowering times from the *Flora of Israel Online*,[25] for the geographical region covered by the *Flora Palaestina*.[26]

Seasonality Based on Individual Plant Remains: Delicate Plant Parts and Unique Species

Since flowering and fruiting occur during specific seasons for most plants, remains of plant organs related to flowering and fruiting may convey seasonal information for the context in which they were found. Their reliability as seasonal indicators depends especially upon the factors affecting deposition and preservation, i.e. taphonomy, and on the seasonality of other plant finds in the given context.

Thus, although barley and wheat both ripen in spring and are harvested in spring–early summer (barley before wheat in the Levant), their grains are stored for daily consumption throughout the year, meaning that their deposition in the archaeological record should be unrelated to seasonality. Even chaff is traditionally stored for fodder, fed to livestock especially during summer and autumn before the replenishment of grazelands in winter, and may also be used for kindling throughout the year.[27] Hence, cereal plant parts, no matter how delicate, should not be considered reliable indicators of seasonality in the Levant.

In addition, seeds of some wild species may linger on the parent plant for several months before dispersal and may continue to preserve on site for a long time before becoming deposited in the archaeological record. Hence, when inferring the season during which individual seeds were deposited, one should consider species-specific dispersal mechanisms and seed hardness. Delicate and ephemeral plant organs, such as flowers, tend to have a short survival time. This makes it likely that they were deposited close to the species-specific season of the given plant part's formation, making them better seasonal indicators. Even among flowers, differences abound in their seasonal specificity and pre-deposition durability, as is evident from three species of which flowers were found in Shivta's Early Islamic middens.

[25] Danin and Fragman-Sapir 2021+. Scientific names of plant species also follow this source.

[26] Zohary and Feinbrun-Dotan 1966–86; Danin 2004.

[27] Dalman 2013.

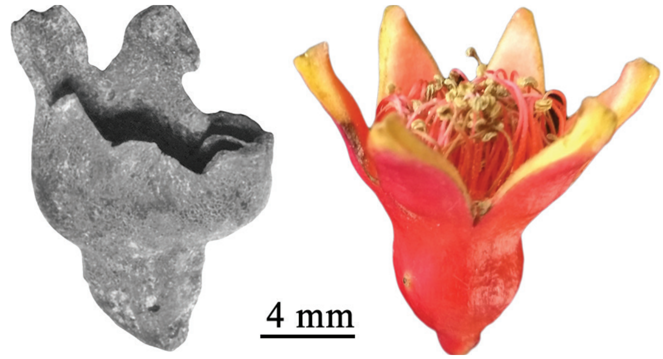

Figure 7.3. Pomegranate (*Punica granatum*) flowers, ancient and modern. A charred flower from Shivta, Early Islamic midden, Area K1 (left) and a recent one (right) (© Daniel Fuks).

Figure 7.4. Shaggy sparrow-wort (*Thymelaea hirsuta*) flowers, ancient and modern. A charred flower from Shivta, Early Islamic midden, Area K1 (left) and a recent one collected by the author [DF] in April 2017, near Elusa (Al-Khalasa) in the Negev (right). Note the remains of hairs, which give the species its name, still visible on the archaeological specimen (left) (© Daniel Fuks).

A couple of pomegranate (*Punica granatum*) flowers were identified from Shivta's midden K1, Loci 162 and 166 (Fig. 7.3). Since the pomegranate flowers mainly from April–June, this might indicate a spring deposit. However, as far as flowers go, those of pomegranate are relatively tough, and it is not uncommon to find pomegranate flowers much later or earlier, either on the tree or fallen beneath it. We cannot rule out the possibility that the ancient pomegranate flowers from Area K1 were late-bloomers, or that they waited some time under the mother tree before being swept up into the fire and eventually dumped in the midden.

Another plant species whose flowers were also found in the Shivta middens is the shaggy sparrow-wort (*Thymelaea hirsuta*) (Fig. 7.4). This wild shrub is

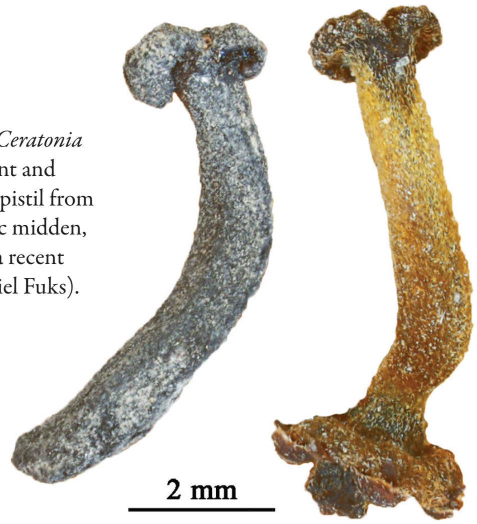

Figure 7.5. Carob (*Ceratonia siliqua*) pistil, ancient and modern. A charred pistil from Shivta, Early Islamic midden, Area K2 (left) and a recent one (right) (© Daniel Fuks).

a common source of twine and kindling in the central Negev; its leaves and seeds are among the most ubiquitous wild plant parts in the Negev Highland middens. Unfortunately, shaggy sparrow-wort has a rather long flowering season, extending from March–July at the least, and often beyond this window on either end.[28]

The most reliably indicative individual plant part for seasonality found in the Negev Highlands middens was a carob (*Ceratonia siliqua*) pistil from Area K2, Locus 151 (Fig. 7.5). Unlike the aforementioned species, and most local plants, the carob does not flower in spring. Its flowering season is August–November and may be considered an indicator of late summer–autumn.[29] Fertilized pistils tend to continue their development into carob pods whereas unfertilized pistils dry out, fall off the flower, and disintegrate. Therefore, the Shivta carob pistil was almost certainly deposited in late summer–autumn and charred while still fresh.

In contrast to flowers and their parts, seeds tend to be hardy and survive several seasons, sometimes through deliberate storage, reducing the likelihood of archaeological deposition close to their season of development on the parent plant. One exception is the delicate seed of the aubergine (*Solanum melongena*). A few aubergine seeds were found in an Early Islamic midden from Shivta (Area E, Locus 504), preserved uncharred under the cover of stones. Incidentally, these are the earliest aubergine seeds discovered in the Levant.[30] Unlike other crop plants found in Early Islamic Shivta, which develop during winter and are harvested in spring–summer, the aubergine is traditionally a summer crop. Furthermore, aubergines tend to be eaten fresh, during the season of seed ripening. Therefore, these seeds' presence could indicate a summer deposition. The main problem with seasonal interpretations based on a single indicative plant part, such as an aubergine seed or a carob pistil, is that they reflect only their own deposition, and not necessarily that of the entire archaeological locus in which they were found. In order to identify locus-based seasonal depositions, the full assemblage of identified wild plants should be considered.[31]

Seasonality Based on Plant Remain Assemblages: Flowering Season Convergence

Due to the plasticity of flowering time, the rarity of actual flowers even in the best-preserved archaeobotanical assemblages, and the likelihood of multiple seasons in a given locus, seasonal identifications should take into account the full plant assemblage for the locus or context in question. Charting the convergence of wild species' flowering seasons is a robust method for identifying a season-specific assemblage.

In Table 7.1, we chart flowering seasons for all wild annuals found in a single 3 litre sediment sample from Locus 162, Early Islamic midden K1.[32] Although each individual species has a slightly different flowering season, they all overlap in March–April. Note that we chart flowering times, rather than fruiting times, because the former were carefully recorded and documented in numerous field studies over the last century.[33] To estimate species-specific fruiting times, as an indication of the archaeobotanical remains' season of formation, we add one month from flowering to fruiting. Allowing some retention time on the parent plant, the data reflect assemblages produced in April–June. The strength of this method rests on the high number of identified species and their unanimous convergence of flowering time. Pre-dispersal parent plant retention is in fact much longer than one month for some species, but not for so many different annual species. Assemblages with non-convergent flowering seasons should be interpreted as assemblages formed by deposition over multiple seasons.

28 Danin and Fragman-Sapir 2021+.

29 Danin and Fragman-Sapir 2021+.

30 Fuks and others (forthcoming).

31 Charles 1998; Dunseth and others 2019.

32 Adapted from Dunseth and others 2019, fig. 10.

33 Danin and Fragman-Sapir 2021+.

Table 7.1. Flowering months of wild annuals identified from Shivta, Area K1, Locus 162. All species presented were identified from a 3 litre sediment sample. Flowering times converge on March–April. Allowing one month between flowering and fruiting, plus some retention on the parent plant after fruiting, this assemblage likely represents April–June activity and deposition (adapted from Dunseth and others 2019, fig. 10).

	Flowering Months											
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adonis dentata		■	■	■								
Aizoon hispanicum		■	■	■	■							
Anagallis arvensis			■	■								
Arnebia decumbens	■	■	■	■								
Avena barbata/fatua			■	■								
Avena sterilis			■	■	■							
Bassia muricata		■	■	■	■	■						
Brachypodium distachyon		■	■	■	■							
Caylusea hexagyna	■	■	■	■	■	■	■					
Chenopodium murale		■	■	■	■	■	■	■	■	■	■	■
Emex spinosa	■	■	■	■	■							■
Fumaria parviflora/densiflora	(■)	■	■	■	■							
Galium aparine			■	■								
Glebionis coronaria		■	■	■	■							
Malva parviflora		■	■	■	■							
Medicago astroites			■	■								
Medicago polymorpha/marina		(■)	■	■	(■)	(■)						
Melilotus sulcatus			■	■	■							
Neslia apiculata	■	■	■	■								
Phalaris minor			■	■	■	■						
Phalaris paradoxa			■	■	■	■	■	■				
Plantago ovata	■	■	■	■								
Silene colorata/decipiens		■	■	■								
Spergula fallax	■	■	■	■	■	■						
cf. *Trifolium campestre*		■	■	■								

One issue with this method is that, in the Negev, the vast majority of wild plant species flower in the spring. In theory, we could have a problem of equifinality in that even assemblages produced in winter might contain only seeds of wild plants which flower in spring. While there are other-season species which should be sought in the archaeological record, perhaps the most elegant way around the problem of seasonal equifinality is analysing the botanical remains of dung pellets.

Seasonality from Special Contexts: Dung Pellets

Dung has long been recognized as a potential source of plant remains in archaeobotanical assemblages.[34] Much debate and research has centred on identifying dung-derived archaeobotanical assemblages with relevance to formation processes and archaeological interpretation.[35]

34 Miller 1977; Bottema 1984; Miller 1984; Miller and Smart 1984.

35 Miller 1996; 1997; Hillman, Legge, and Rowley-Conway 1997;

Table 7.2. Flowering months of wild annuals in dung pellets from Shivta, Area K1, Locus 162. Species presented were identified from a small assemblage of dung pellets (photographed in Figure 7.6). In two pellets, convergence of identified species' flowering times indicates May–June activity, adding one month from flowering to fruiting plus retention time (adapted from Dunseth and others 2019, fig. 10).

Species by pellet	**Flowering Months**											
Locus 162 — Pellet 1	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Anagallis arvensis			■	■								
Pulicaria incisa	■	■	■	■	■							
cf. *Trifolium campestre*		■	■	■								
Locus 162 — Pellet 2												
Aizoon hispanicum		■	■	■	■							
Cynodon dactylon				■	■	■	■	■	■	■	■	■
Locus 162 Combined Pellets												
Aizoon hispanicum		■	■	■	■							
Anagallis arvensis			■	■								
Cynodon dactylon				■	■	■	■	■	■	■	■	■
Malva aegyptia	■	■	■	■								
Pulicaria incisa	■	■	■	■	■							
cf. *Trifolium campestre*		■	■	■								

Figure 7.6. Charred dung pellet sample dissected for seeds, from Shivta Area K1, Locus 162. The assemblage includes four intact pellets and fragments of at least three others. Of the four intact pellets, one contained seeds of three different species, and one contained seeds of two species (pellets 1 and 2 in Table 7.2). Seeds of six plant species were found in the combined dung-pellet assemblage, which point to May–June seasonality (Table 7.2) and agree with the April–June seasonality identified from the corresponding sediment sample from the same locus (Table 7.1).

In the course of the present authors' research on this topic, intact dung pellets proved to be a wellspring of information conveyed by plant remains within them — beyond taphonomy and including seasonality.[36] In our study of dung pellets' botanical contents from Shivta's Early Islamic middens, a couple of individual pellets yielded enough identifiable seeds to determine the season in which they were produced (Table 7.2; Fig. 7.6). The potential implications of this result are profound. Each pellet is produced within a matter of days or hours from ingestion, during which time the animals producing it could have travelled a limited (but not insignificant) distance. Hence, the dung pellet is a unique type of archaeological micro-context providing a precise time capsule of pastoral activity. Significantly, the Early Islamic Shivta dung pellets analysed were produced in the very same April–June season identified in corresponding sediment samples.[37] This supports the archaeological evidence for rapid accumulation of these trash sediments since protracted accumulation should have yielded species spanning different seasons.

Charles 1998; Valamoti and Charles 2005; Shahack-Gross 2011; Wallace and Charles 2013; Baeten and others 2018; Smith and others 2019; Spengler 2019b; see summary in Fuks and Dunseth 2021.

36 Dunseth and others 2019; Fuks and Dunseth 2021.

37 Dunseth and others 2019.

Discussion: Archaeobotanical Investigation of Seasonality Costs and Benefits

Archaeological plant flowers, seeds, and dispersal units are among the best sources of evidence for determining the season(s) in which a given archaeological context accumulated. The contextual unit of seasonal analysis may vary from entire sites, to specific strata in archaeological sections, to individual dung pellets. Plant remains provide empirical data that can be measured and analysed through multiple methods. However, the collection of archaeobotanical material is a painstaking task, and the dearth of evidence from most archaeological contexts, especially in later historical periods, may result from several methodological biases:

Type-I error: excavation bias. Among various methodological biases resulting from excavation activity, those most affecting investigation of archaeobotanical seasonality concern sieving and sampling strategies as well as context-based variation in plant-remain richness. Most types of seeds will not be retrieved without sieving, and floral compositions, including the presence and proportions of plant species, will vary at each mesh size. In addition, species richness varies significantly by archaeological context. Most archaeological contexts are too poor in plant remains to produce meaningful convergences of species-specific seasonality. One advantage of the NEGEVBYZ project is its focus on organically rich middens. Each 3 litre midden sediment sample yielded hundreds, sometimes thousands, of identifiable plant parts representing dozens of plant species. This richness enabled analysis of flowering season convergence among wild annuals, exemplified above. In such contexts, application of a sophisticated sifting strategy was essential, and all excavated material was sifted in one of three different ways, enabling distinct resolutions of analysis. Most excavated material was sifted on site through 5 mm mesh. Wet-sieving through 1 mm mesh was performed on two buckets (~ 20 l.) from each excavated locus to maximize fine-scale retrieval of small artefacts and organic remains. In addition, selected 3 litre sediment samples were collected from each midden stratum or locus identified by the excavators and pre-sifted with 0.3 mm sieves. Depending on the sediment composition, they were then processed either by flotation or by dry-sieving in graduated sieves of 4 mm, 2 mm, 1 mm, 0.5 mm, and in some cases, 0.3 mm mesh. In many instances, double samples were prepared for both flotation and dry-sieving.

Type-II error: collection bias. Even when samples are properly sieved and sufficient material collected, plant remains will be available for further analysis only after separating identifiable plant parts from other particles. This demands laborious 'picking' and sorting efforts. Biases introduced during this stage include limits on time and funding affecting the quantity of sorted material, the expertise of the person sorting, and the use of visual aids. In the NEGEVBYZ project, we invested great efforts in limiting such sources of bias, including thousands of student paid hours for picking samples processed by wet-sieving (1 mm mesh), alongside processing and sorting of flotation samples (0.3 mm mesh) by a full-time archaeobotanist (DF). We estimate that each bucket of 1 mm sieved rubbish-midden sediment required nearly thirty hours of picking, on average, by students not trained in archaeobotany and without visual aids. Meanwhile, precise sorting by a trained archaeobotanist using a stereo microscope may take even longer but minimizes collection bias. In a study of major crop plant ratios based on thousands of grape, barley, and wheat seeds retrieved from 2 mm sieves, we found that the two sorting methods yield essentially equivalent quantitative results for large seeds.[38] Since most domestic plant seeds fall in this size category (fig nutlets being a notable exception in the Mediterranean region), picking by untrained archaeobotanists can provide general information on major crop types. However, the study of wild annuals — so important for seasonality — requires skilled, microscope-based sorting and identification using an appropriate reference collection. In the case of dung pellets, dissection and retrieval require even greater care. Most of the plant finds relevant for seasonal identification described above were retrieved through skilled sorting, using a stereo microscope. The only exception is the pomegranate flowers, whose retrieval may have been due to the larger sample size processed by coarse sifting and unskilled sorting.

Type-III error: analytical bias. Identifying plant remains is a difficult task and requires much skill, patience, and an appropriate reference collection. Most wild plant species have limited geographical ranges and, as result, so do most reference collections and archaeobotanists. Experience and expertise also vary among archaeobotanists. Therefore, it may sometimes be problematic to compare assemblages collected by scholars with different backgrounds and access to local reference

38 Fuks and others 2020, SI appendix.

material, which is crucial for precise taxonomic identification. For the NEGEVBYZ project, taxonomic identification of plant remains was made possible using the Israel National Collection of Plant Seeds and Fruits (at Bar-Ilan University), as well as the Computerized Key of Grass Grains for identifying grass grains.[39]

* * *

Despite the above methodological biases and resulting economic constraints to archaeobotanical research, 'seek and ye shall find' is an appropriate maxim for the study of ancient plant remains. The NEGEVBYZ project is one of the leading case studies among ongoing archaeological projects which apply sophisticated strategies for sifting, sorting, and identifying archaeobotanical remains. As such, it joins parallel projects conducted mainly on prehistoric sites,[40] and more recently also on historic sites,[41] of the Mediterranean region.

For Future Research

All types of archaeobotanical indicators for seasonality discussed above rely on the seasonal specificity of flowering and fruiting. One limitation of this approach is that plant flowering times are often heavily skewed to a particular season in a given study region. This means that seasonal depositions will be much more recognizable for certain seasons and less so for others. Failure to consider this bias can result in erroneous interpretations about human activity at a site. Meanwhile, researchers investigating seasonal archaeological depositions will face the challenge of developing reliable indicators for all seasons of the year. In the Negev Highlands, most wild plants flower in spring; few do so in late summer and autumn, although notable exceptions include the annuals *Salsola inermis*, *Salsola tragus*, *Lactuca serriola*, and the shrub *Noaea mucronata*. Meanwhile, the available species-specific seasonality data in local floras is based on flowering times throughout the wider (*Flora Palaestina*) region. Field trips to collect seasonal information on fruiting and dispersal among the flora of the specific study region (Negev Highlands) over several seasons and years can significantly improve seasonal interpretations of archaeobotanical assemblages.

Identifying sub-annual seasonal deposition has important implications for reconstructing economic trends, which depend upon the chronological resolution of analysis. Just as with modern gross domestic product (GDP) growth models, seasonal effects can be incorporated in archaeological-economic models if they can be identified and understood. For instance, Christmas consumerism is corrected for in modern quarterly economic growth estimates.[42] Analogous seasonal peaks in ancient and traditional Mediterranean societies might involve harvesting times of crops with different ripening times, including barley, wheat, grapes, dates, and olives. Archaeologically reconstructed economic trends almost never go beyond decadal resolutions, at which seasonal effects become invisible;[43] hence the possibility of identifying seasonal economic effects in archaeological sections of rapid depositions could be ground-breaking.

One important source for seasonal identification in short-term archaeological deposits is coprolites, or archaeological faeces, which have the unique characteristic of being produced and initially deposited within just a few days. The main advantage of the dung pellet is that it forms a highly specific spatio-temporal context, and an individual herbivore dung pellet can attest to grazing in a particular season. It follows that dung layers can be analysed for seasonal homogeneity, and a multi-annual assemblage of dung pellets should inform upon seasonal grazing patterns. Herbivore dung pellets, particularly of the main domesticated animals, are found in a variety of archaeological contexts, including, but not limited to, middens. In caves and rock shelters used for stabling animals, layers of dung deposits may accumulate — sometimes being deliberately burned in situ.[44] Such deposits often preserve stratigraphic sequences of dung which was not moved since initial deposition. These offer the highest likelihood of discovering intact season-specific layers. In hearths, pits, and rubbish middens, dung pellets usually represent secondary deposition, often after being collected and used for kindling. Yet, even in such contexts, dung pellets have been found whose contents indicated a specific season consistent with the rest of the sample, as demonstrated above.[45] Adding different

39 Kislev and others 1995; 1997; 1999.

40 E.g. PLANTCULT; Weiss 2017 and references.

41 E.g. SICTRANSIT.

42 Miron 1996.

43 Fuks and others 2020; Izdebski and others 2020.

44 Brochier, Villa, and Giacomarra 1992; Macphail and others 1997; Rosen and others 2005; Angelucci and others 2009; Burguet-Coca and others 2020.

45 See Dunseth and others 2019 for further details; also Fuks and Dunseth 2021.

biomolecular and chemical methods to future multi-proxy archaeobotanical investigation of herbivore dung will produce invaluable high-resolution seasonal reconstructions. Direct indicators of flowering and fruiting, through extraction of both pollen and seeds from the same pellet (preserved by desiccation, waterlogging, or freezing), should yield highly specific seasonal identifications. Phytoliths, $\delta^{15}N$ and $\delta^{13}C$ isotopic ratios, and grass lignin structure should also be explored as complementary proxies of dung pellet seasonality.[46] If seasonal deposition of individual loci can be identified, then in theory, formation processes of an entire archaeological section could be inferred. In a scenario where a stratum-by-stratum seasonal sequence can be reconstructed, archaeologists could determine how many seasons (and years) are represented in an archaeological section, with potentially profound implications for precision chronology.

Such scenarios are still a far cry from what we can say about seasonality in Shivta, or other archaeological sites. However, archaeologists should bear them in mind and keep on the lookout for contexts with this sort of potential. Expanded datasets of seasonal identifications will contribute significantly to research on the long-term development of agriculture and pastoralism, ecosystem transformation, and our understanding of the rhythms of ancient daily life.

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[46] Zazzo and others 2015; Burguet-Coca and others 2020; Landau and others 2020.

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