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► **To cite this version:**

Jwana Chahoud, Emmanuelle Vila, Moussab Albesso. Livestock management in the Northern Levant during the first millennium BCE. 2022. halshs-03916919

HAL Id: halshs-03916919

<https://shs.hal.science/halshs-03916919v1>

Preprint submitted on 2 Jan 2023

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Livestock management in the Northern Levant during the First Millennium BCE

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Abstract

The economy of Levantine societies in the first millennium BCE was based on animal husbandry and the use of animal life products. New data from Iron Age sites in the Lebanon and Syria are analysed in this paper. The investigation of livestock management through the study of archaeological animal bones and their measurements reveals specialised zootechnies. Size variability is observed, especially among sheep and cattle. This heterogeneity suggests that management techniques were directed towards ensuring the necessary supply of animal types to provide the required secondary products in coastal and hinterland, small or large centres. This response to market demands was possible by using different husbandry (zootechnies) strategies and by large-scale trade activities in the region.

Keywords

Northern Levant; Iron Age; Small/large centres; Husbandry practices; Animal size; Log ratios

1. Introduction

Research on the transition from the Late Bronze Age to the Iron Age in the Northern Levant in general has not so far considered faunal and livestock data in the studied proxies. This paper is a first synthesis of the animal economy from the Northern Levant for the Iron Age. Such analyses, focusing on zooarchaeological data as a means for reconstructing subsistence patterns and dietary practices, are sorely needed in studies of the Iron Age. Archaeozoological reports from the Northern Levant are still relatively uncommon, and while several preliminary studies have been attempted in recent years, the dataset are far from sufficient to pursue general analyses of dietary preferences or animal management strategies throughout the Iron Age (Iron Age I-II-II). The Levantine Iron Age is characterized by a variety of regional patterns and cultural diversity (Porter, 2016).

This study contributes to the comparison at a larger scale between different regions of Mediterranean basin in the first millennium BC. (this special volume). Hence, this paper focuses on drawing a regional synthesis of livestock management for the northern Levant.

41 This paper uses original data to analyse animal husbandry (subsistence, products
42 and size) to assess to what extent the social, cultural and climate changes have
43 affected the livestock management. We use the term livestock management to focus
44 especially on the identification of impacts of the zootechny on animal sizes and
45 shape.

46 Our study considers faunal data from several Iron Age sites and compares them with
47 Late Bronze Age sites, in order to address the following questions: 1) Are Late
48 Bronze and Iron Age societal changes, particularly a return to rural life, reflected in
49 husbandry practices? Are the climatic changes often invoked as one of the causes of
50 the collapse at this pivotal transition evidenced by the exploitation of domestic
51 animals? Are the phenotypes (size, robustness) of domestic animals similar for both
52 periods? Are sheep, goat, and cattle types in the Northern Levant comparable in
53 coastal and inland regions?

54 **2. Chrono-cultural setting**

55 This paper examines archaeozoological data from the Iron Age (IA: 1200-350 BCE)
56 settlement of the Northern Levant (Lebanon and south-western part of Syria).

57 The transition from the Late Bronze Age (ca. 1550 BCE) to the late thirteenth-
58 eleventh centuries is marked by instability and the collapse of major political entities,
59 accompanied by climatic changes (Killebrew et al., 2013; Chiti, 2015; Knapp and
60 Manning, 2016; Karakaya and Riehl, 2019). Nevertheless, the aridity and climate
61 changes recorded at the end of the Late Bronze Age (LBA) may have not been
62 sufficiently abrupt to cause social collapse and the end of the palatial era and
63 kingdoms (Knapp and Manning, 2016). Furthermore, archaeobotanical data from the
64 Northern Levant clearly show the increased cultivation of drought-susceptible plants
65 (water-demanding field cereals and leguminous plants along with arboricultural
66 crops) during the Iron Age, in spite of deteriorating climate conditions (Karakaya and
67 Riehl, 2019).

68 The destruction of several large cities, especially in the Southern Levant, has been
69 linked to the invasion of the coastal Levant by the so-called "Sea People".
70 Nevertheless, recent studies have shown that the phenomena is far more complex
71 and the fate of several cities is variable according to their location and importance
72 (Hitchcock, 2011; Gilboa, 2013; Maeir, 2018). Large centres of the North, such as
73 Ugarit and Qatna, experienced destruction and abandonment at the beginning of the
74 Iron Age (IA) witnessing the end of the era of large cities under palatial control.
75 However, recent discoveries revealed that several northern Levantine settlements
76 demonstrate continuity in traditions from the Late Bronze Age onwards. They show
77 that after a short period of abandonment (e.g., Kamid el-Loz), or after destruction
78 (e.g., Ras Ibn Hani and Tell Afis), a direct transition took place with no gap for the

79 Iron Age I (Killebrew et al., 2013; Sader, 2013). Therefore, coastal sites in the
80 Northern Levant show a combination of continuity in LBA traditions in terms of
81 material culture and the introduction of new incoming repertoire from the Eastern
82 Aegean and Cyprus (e.g., Tell Kazel, Ras Ibn Hani and Sidon), (Killebrew, 1998;
83 Badre et al., 2005; Welton and Charaf, 2020). Meanwhile, hinterland settlements
84 were transformed into agricultural rural villages (e.g., Mishrifeh/Qatna and Kamid el-
85 Loz), (Al-Maqdissi and Souleiman, 2008; Wagner-Durand, 2020). On the other hand,
86 monumental architecture appears by the eleventh century, marking re-urbanization,
87 especially at Tell Afis, Aleppo, and 'Ain Dara (Abu Assaf, 1990; Mazzoni, 2000;
88 Gonella et al., 2005).

89 The Iron Age II began with the expansion at the beginning of the ninth century of
90 territorial forces: the Arameans, the Neo-Hittites and the Assyrians. Two phases of
91 re-urbanization and reconstruction of the main cities are evidenced with the
92 construction of residential and monumental quarters (Iron Age IIA - 9th century BCE
93 and IIB- 8th century BC) (Mazzoni, 2000; 2013b; Steiner, 2013). The cities of the
94 Levant are considered as small and regional states that share the same culture and
95 develop a large-scale economy between them and with Cyprus and Greece,
96 regardless of instability and wars. Later on, the Iron Age III is marked by the
97 emergence of multifaceted components, such as the Arameans, Phoenicians,
98 Philistines and others, interacting with powerful forces, such as the Assyrians,
99 followed by the Babylonians and the Persians (Ehrlich, 1996; Lipi nski, 2000;
100 Markoe,2000; Holger, 2013). During the seventh century BCE, a new process of
101 Assyrian urbanization took place, culminating in the cultural unification of the region
102 (Mazzoni, 2000; 2013b). The last phase of the IA III (seventh and sixth centuries
103 BCE) is characterized by a new territorial organization, changes in urbanism, and a
104 consistent transformation of the material culture, along with the diffusion of Assyrian
105 wares. For coastal regions, local cultures in Phoenicia gradually developed through
106 their connexion with other Mediterranean societies, the Cypriots and the Greeks
107 (Mazzoni, 2013b). With the changes occurring in the first millennium BCE, we would
108 expect that the economy based on animal husbandry must have been affected. The
109 hypothesis noted on culture material is that of a shift to rural economy in IA I, and
110 from a state economy to large scale open trade economy in IAII-IAIII. Therefore, we
111 would expect a significant change in animal exploitation between the large centres of
112 LBA and the shift to rural economy in the beginning of Iron Age. This would explained
113 by for example the use of mixed economy attested in rural settlement or specialized
114 economy attested in large centres. We would expect for independent city-states of
115 different kingdoms of the Levant to have different pattern of animal economy and a
116 variety of animal types (sizes, age.) especially due to the increasing trades.
117 Meanwhile, the influence of the incoming power of the Assyrian in the Levant might
118 have had a certain power to control the animal production and economy. Therefore, it
119 is expected to have a centralized similar economy and animal management in the
120 region during the IA II-III.

121 Furthermore, given the climatic changes throughout the transition between Bronze
122 and Iron Ages, it is expected that livestock management to have adapted to this
123 increased aridity in term of animal breeding practices. And in Iron Age in general,
124 with the variability of social and political patterns, livestock management would be
125 expected to be different between rural/urban and/or large/small centres. These
126 challenges and adaptation to both cultural and climate changes would have
127 eventually affected the subsistence economy and animal sizes. Certain taxa were not
128 exploited in large centres.

129 **3. Material and Methods**

130 3. Material and methods A total of 38,000 animal remains were analysed in this study
131 from fourteen Iron Age sites in the northern Levant (Table 1, Fig. 1). In addition, nine
132 faunal assemblages dating to the Late Bronze Age are also included in the analysis
133 to address the diachronic evolution of animal roles and types (Table 1). We based
134 our analyses on the main livestock species exploited for consumption in the region:
135 caprines (sheep and goats), cattle, and pigs. The relative frequencies were
136 calculated using the number of identified specimens (NISP) of the domesticated
137 species. In this analysis, the Iron Age is taken as a whole period without subdivisions.
138 Indeed, published faunal studies and fauna from ongoing excavations do not always
139 distinguish between the different stages of the Iron Age (I-II-III). Some of the
140 assemblages discussed here are published for the first time and complete
141 descriptions of animal exploitation from Iron Age sites, such as Tell Kazel, Gindaris,
142 and Ras Ibn Hani, are not available elsewhere. Moreover, when phasing is published,
143 assemblages are sometimes very small and not significant; less than 100 remains for
144 NISP comparison. In addition, the measurable elements are not available by phases
145 for all sites (for example, bone measurements were divided by phases for Kamid el-
146 Loz, Tweini, and Nebi Mend only, yet they were not significant for comparison for the
147 different species). Therefore, we grouped animal remains for each period (IA and
148 LBA), to compare faunal assemblages of several hundreds or even several
149 thousands of remains and to include animal sizes from all analysed sites (Table 1).

150 **3.1. Sites and assemblages**

151 The animal remains considered here are from five coastal and nine hinterland Iron Age
152 sites in Syria and the Lebanon (Tab.1, Fig.1). For comparative purposes, animal
153 remains from nine Late Bronze Age sites were included in the study: five on the coast
154 and four in the hinterland.

155 Most of these sites were occupied during the Late Bronze and the Iron Age, except
156 for Alalakh, Ugarit (LBA), Ain Dara, Gindaris, Qarqur, Al Nasriyah, and El Burak (IA).
157 In addition, ten IA sites were occupied during the transition phase between the LBA
158 and IA I (Table 1). The LBA sites are mainly large centres while Iron Age settlements

159 are diverse; eight Iron Age sites are small centres or dwellings, five are large centres
160 and one is an Iron Age temple and residential complex (Ain Dara), (Table 1). For the
161 Iron Age settlements, three are larger than 30 ha, six are between 10 and 22 ha and
162 one, El Burak, is less than 10 ha. For this study, we only considered mammal
163 remains for the comparison and included wild and domesticated ungulates for the
164 total NISP per site (presented in Table 1). For the IA fauna, Tell Afis and Tweini
165 yielded the highest total of animal remains with 15,770 and 7943 NISP each,
166 respectively. Meanwhile, six sites yielded between 1000 and 3000 remains and six
167 assemblages contained less than 1000 NISP (Table 1). On the other hand, the LBA
168 faunal remains are mainly from Nebi Mend and Kamid el-Loz, with 11,163 and
169 11,526 NISP, respectively, while six sites yielded a total of between 1000 and 6000
170 NISP, and only one, Tell Afis yielded 357 NISP. The heterogeneity of this
171 assemblage is related to the differential depositional context of the assemblages
172 (e.g., temple, pits, public buildings, courtyards, etc.) but also to the differential
173 recovery of bones (sieved from Tweini and Sidon vs not sieved from other sites), the
174 method of excavations (old versus recent excavations) and also the identification
175 methods of animal remains. To reduce these factors, we considered the NISP of
176 domestic mammals by a group of caprines, cattle and pigs that are mostly collected,
177 identified and measured by archaeozoologists. Furthermore, closed and special
178 contexts such as burials and deposits as long as fill and levelling layers were not
179 considered in the study. These sites are located in regions corresponding to two
180 different bioclimates: one benefiting from Mediterranean climatic conditions and the
181 other from variable aridity conditions, strongly influenced by the proximity of arid
182 margins (Badiyah el Sham) in the east and the desert (Hamad) in southeast Syria
183 (Fig. 1). The sites are presented according to their geographical position on the coast
184 or the hinterland, from the north to the south. In the following, the analysis is
185 conducted according to the geographical regions (coastal/hinterland) to investigate
186 the evolution of livestock management from coastal sites that have different cultural
187 interactions than those of the hinterland. At the beginning of the Iron Age, coastal
188 cities are the most influenced by the changes that occurred (urban to rural
189 settlement). Afterwards, in the IA II and IA III, hinterland sites became parts of
190 kingdoms that progressively incorporated the Assyrian empire while coastal sites
191 functioned as trading ports and remained as independent city-states that paid tribute
192 to the Assyrian empire (Sader, 2013; Steiner, 2013).

193 **3.1.1. Coastal sites**

194 Ras Ibn Hani is a rocky promontory on the Syrian coast. It was a peninsula, protected
195 by two bays, with a residential occupation in the Late Bronze Age associated with the
196 Ugarit site, five kilometres away (Lagarce and Puytison-Lagarce, 1978). The capital
197 of the Ugarit Kingdom collapsed in the LBA, whereas Ras Ibn Hani was reoccupied
198 after the destruction of the early eleventh century BCE. The site remained occupied
199 throughout the Iron Age (IA I-II-III) (Lagarce et al., 1987; Lagarce and Hasan, 2008).
200 The faunal remains come from Iron Age pits and domestic dwelling levels.

201 Tell Tweini (ancient Gibala) is located on the Syrian coast. The site was part of the
202 Ugaritic kingdom and was a port settlement with commercial activities during the Late
203 Bronze Age. Evidence of occupation during the IA I is scarce. During IA II and IA III,
204 an urban occupation with public and private buildings developed across most of the
205 tell (12 ha), (Bretschneider and Van Lerberghe, 2010). The mammal bones were
206 recovered from domestic and religious buildings, streets, pits and wells (Albesso,
207 2018; Linseele et al., 2019).

208 Tell Kazel is located in the Syrian Akkar coastal plain, a few kilo metres from the
209 shoreline and the northern Lebanese border. The site is considered the ancient
210 Sumur/Simyra, an Egyptian administrative centre that flourished in the Levant during
211 the Late Bronze Age. The transition from the LBA to the IA is well attested in Tell
212 Kazel. In addition, the site yielded a complete Iron Age sequence (IA I-II-III). The IA
213 occupation corresponds to a rural settlement with scattered structures and
214 constructions, including a small shrine in the IA IB. Settlement expansion in the IA II
215 levels confirms new urban growth (Badre and Gubel, 1999; Chiti, 2015). A large
216 number of animal bones were recovered from the LBA residential area and temple
217 and the IA settlement levels (rooms and dwellings) of Tell Kazel. The small amount
218 of IA animal remains published in this paper is because the ongoing study was halted
219 by the conflict in Syria (Chahoud, 2015).

220 Sidon is located on a rocky promontory protected by two bays on the southern
221 Lebanese seashore. It was an important commercial centre during the LBA and
222 recent excavations demonstrated continued occupation of the site during the
223 transition to the IA. Temples were erected around the twelfth century BCE and were
224 continuously occupied with at least eight phases identified (Doumet-Serhal, 2013;
225 2021). Animal remains were recovered from temples and residential quarters from
226 the LBA (Chahoud, 2015). The bone remains were recovered from Iron Age I, II and
227 III occupation levels, mainly from temples (Chahoud, 2022).

228 Tell El Burak is a small fortified coastal settlement in southern Lebanon, founded
229 towards the end of the eighth century BCE, when the city-kingdom of Sidon was in
230 full expansion (Kamlah and Sader, 2010). The site was not occupied during the LBA.
231 An agricultural domain was subsequently established during the Iron Age. The faunal
232 remains were recovered from dwellings and workshops (Çakırlar et al., 2014;
233 Vermeersch, 2021).

234 Along with these five coastal sites, two small faunal assemblages are published from
235 the cemetery of Tyre-Al Bass and from Iron Age pits and foundation levels from
236 Jiyeh, on the southern coast of the Lebanon. Animal bones recovered from cremation
237 burials from Tyre-Al Bass are not included in this paper, due to the specific
238 inhumation context, the limited number of remains (264 NISP) and the lack of
239 published measurements. Moreover, for Jiyeh, the animal remains (104 NISP) were
240 recovered from IA features including walls, foundations and pavements in trench
241 tests. This material is problematic as it could be mixed with recent Persian or

242 Hellenistic layers. On account of the limited NISP and the two published
243 measurements, we will not consider this assemblage in the general comparison. The
244 main species identified from both these sites are cattle, sheep/goats and pigs
245 (Montero, 2014; Piątkowska-Matecka, 2017).

246 For the LBA, for comparative purposes, we also included the faunal remains from the
247 site of Alalakh in Turkey, the northernmost coastal site (Çakırlar et al., 2014).

248 **3.2.2. Hinterland sites**

249 The site of Ain Dara in the Amuq Plain of Syria extends over nearly 50 ha, and is
250 known for its monumental temple remains (Abu Assaf, 1990; Stone and Zimansky,
251 1999). The Iron I-II transition and the Iron II bone remains were recovered from
252 residential and domestic buildings, as well as workshop areas and pits (Frey and
253 Marean, 1999).

254 Gindaris is the main mound along the Afrin River. It extends over an area of around
255 20 hectares. Two phases dating back to the Late Bronze to the Iron Age transition
256 period (Neo-Assyrian and Late Hittite/Aramaic times) (circa 1100 to 600 BCE) have
257 been identified (Weiss, 1997). The faunal remains were recovered from Iron Age pits
258 and structures.

259 Tell Afis, identified as Aramean Hazrek, represents the most complete Late Bronze–
260 Iron I stratigraphic sequence in the Northern Levant. It is located on the north-
261 western Syrian plateau. During the LBA, Tell Afis was an urban commercial centre at
262 a crossroads between the littoral and inland Syria. The Iron Age I levels of this site
263 are characterized by domestic structures. The settlement reached its greatest
264 dimensions (30 ha) during the IA II-III (Mazzoni, 2013a). The site was conquered by
265 the Assyrians in 738 BCE and transformed into a provincial centre, the seat of a
266 governor. The bones were recovered from LBA administrative and residence
267 buildings (Wilkins, 2000), and from IA I-II-III monumental temples, official and
268 domestic buildings (Carenti, 2012a; 2012b).

269 Tell Qarqur is a 12-hectare-mound located in the lower Orontes River Valley. The
270 excavation uncovered a well-preserved transitional Iron Age I/II phase (1200–500
271 BCE), (Dornemann, 2012). The faunal remains were recovered from IA I courtyards,
272 with pits and storage structures, and from IA II domestic dwellings (Grossman, 2008).

273 Tell Tuqan is located in the Matkh Basin. The Upper Town was densely occupied
274 during IA II-III (Baffi and Peyronel, 2014). No public or cult buildings have been
275 found, but the building techniques used for private houses reflect various social
276 strata. The faunal remains were recovered from private dwellings (Minniti, 2014).

277 The Iron Age urban settlement of Al Nasriyah covers about 70 ha and is located in
278 the middle valley of the Orontes. A cemetery with cremation practices was identified
279 on the site for the IA. The site was occupied in the Middle Bronze Age and destroyed

280 around 1500 BCE (Al-Maqdissi et al., 2010). Iron Age II bone remains were
281 recovered from domestic and public buildings (Renard, 2010).

282 Tell Mishrifeh (ancient Qatna) was a flourishing city during the Late Bronze Age,
283 destroyed by the peoples of the sea. The site appears to be occupied again only from
284 the end of the Iron Age I and the beginning of the Iron Age II onwards (Morandi
285 Bonacossi, 2013). The earliest Iron Age levels recorded so far date to the late tenth–
286 early ninth century BCE (IA IC small village). During the eighth century BCE (Iron
287 IIB), Qatna was one of the main southern regional centres of the Aramaean kingdom
288 of Hamath. The faunal remains were recovered from private dwellings, official
289 buildings, and storage areas (Vila and Gourichon, 2007; Albesso, 2018).

290 Nebi Mend (Qadesh-on-the-Orontes) was occupied discontinuously from the seventh
291 millennium BCE to the mid-first millennium CE (Parr, 2015). The Late Bronze Age
292 city, Kadesh, at the crossroads of the Mittanian, Egyptian and Hittite Empires, was
293 destroyed by the Sea People. It was reoccupied in the Iron Age. The faunal remains
294 were recovered from LBA and IA I to III domestic buildings and deposits (Grigson,
295 2015).

296 Kamid el Loz (ancient Kumidi) is located in the Bekaa Valley. The main occupation
297 dates to the Bronze Age when Kumidi was an urban regional centre with a palatial
298 complex, temples and artisanal workshops. The LBA II city was then completely
299 abandoned and a new rural settlement was established in the early IA until the IA II.
300 Moreover, the site was transformed into a burial ground in the IA III ([Heinz 2016](#)).
301 The faunal remains were recovered from domestic houses and activity areas (1200-
302 539 BCE), (Bökönyi, 1990).

303 **3.2. Method**

304 The dataset and related references are summarised in Table 1, whereas the
305 locations of the studied sites are presented according to their bioclimate in Fig. 1. To
306 address the questions mentioned above and to reconstruct livestock management
307 during the first millennium BCE, we focus on the characterization of husbandry
308 practices and the identification of animal sizes and types.

309 **3.2.1. Quantification**

310 The first point to investigate is the comparison of the faunal spectra from the different
311 sites using the relative frequency of the NISP. The NISP is the available and
312 standard data used for most archaeozoological studies in the region. The total NISP
313 figuring on the histograms in Figs. 2 and 3 represents the sum of all four species:
314 sheep, goats (and unidentified sheep/goats), cattle, and pigs. Therefore, the
315 frequency of each species is calculated from the latter total. The ratio between sheep
316 and goats is calculated using the available NISP. Unfortunately, culling profiles could
317 not be included in this study to identify husbandry practices due to the multiple
318 methods used to record the age of slaughter of animals in each site and to the
319 complete lack of data in a few cases. Therefore, it was not possible to compare the
320 heterogenous mortality profiles.

321 **3.2.2. Biometrical data**

322 In order to identify animal types, we analysed bone measurements from 11 sites with
323 biometric data (the IA sites mentioned in Table 1 and LBA Ugarit). The sites were
324 classified by chronology and the analyses were first conducted between sites from
325 the same period (IA and LBA) for different geographic regions (coastal, hinterland),
326 and secondly by regrouping all the sites from each period according to their
327 geographical region. We analysed the biometric dataset using the Logarithmic Size
328 Index (LSI) method (Meadow, 1999), to assess changes in animal size. This method
329 is appropriate for assemblages with very fragmented faunal remains, and scarce
330 measurable skeletal parts. Each measurement is converted into logarithms and then
331 compared to a standard individual ($LSI = \log X - \log \text{standard}$, with 'X' being the
332 measurement of the archaeological specimen, with 'standard' being the
333 corresponding measurement of the reference individual). Three dimensions can be
334 taken on most of the bones according to anatomical orientation; length, width and
335 depth. These dimensions reflect different aspects; length indicates stature, while
336 width and depth are related to body mass (Pöllath and Peters, 2005). This is the
337 reason why length and width/depth measurements have not been mixed in the
338 analyses. Only fused post-cranial bones and well-developed bones (astragalus) that
339 have reached their maximum size were considered. Due to the difficulties in
340 differentiating sheep and goat phalanges, these bones were not included in the LSI
341 for these taxa, whereas they were considered in the cattle dataset when the
342 identification of the bones was possible (Forelimb/hindlimb according to (Dottrens,
343 1946). The nomenclature of measurements is detailed in S.4 and follows (Driesch,
344 1976).

345 Log ratio calculation and analysis were carried out with the package *zoolog* (Pozo et
346 al.) in R 4.0.3 (R Core Team, 2020). In *zoolog*, we chose to extract one grouped log
347 ratio value by length and one by width to avoid overrepresentation of bone elements
348 with the method of priority given to the most frequent measurements. For length, the
349 order of priority is GL, GLI, GLm, and HTC. For width, the order of priority is BT, Bd,

350 Bp, SD, Bfd, and Bfp (Pozo et al.). Measurements of bone depth were comparatively
351 rare and not included. The available reference standards were used by default in the
352 Zoolog package for sheep and goats (Clutton-Brock et al., 1990), cattle
353 (Trentacoste et al., 2018), and pigs (Stopp and Deschler-Erb, 2018). The standard
354 used for sheep (*Ovis aries*) is the mean measurement of a group of male Soay sheep
355 of known age (Clutton-Brock et al., 1990). Soay sheep are one of the smallest and
356 the last modern populations of primitive domestic sheep. The standard for goats
357 (*Capra hircus*) consists of the mean measurements of a group of a feral flock of goats
358 of unknown age and sex collected on the Holly Island of Scotland (Clutton-Brock et
359 al., 1990). The cattle (*Bos taurus*) standard is a female cow dated to the Early Bronze
360 Age from Minferri in Catalonia (Trentacoste et al., 2018). Finally, the standard used
361 for pigs (*Sus scrofa*) is a museum reference specimen from Basel (Inv. nr. 1446); a
362 male aged 2–3 years old with a live weight of 120 kg (Stopp and Deschler-Erb,
363 2018). Descriptive data of LSI values are presented in supplementary table S14.

364 **3.2.3. Data visualisation and statistical analyses**

365 Data visualisation and statistical analyses were performed to assess changes over
366 time and between sites and bioclimates with histograms of relative NISP frequency
367 and one-way ANOVA between sites. Correspondence analysis (CA) were used to
368 explore the correlation between livestock frequencies by site, by bioclimate areas and
369 by types of settlement (S.1). The CA were conducted in PAST (Hammer et al., 2021).

370 For the Log ratios, we conducted data visualisation and statistical tests of LSI values
371 by element for each species to avoid the overrepresentation of one bone element by
372 site, which can alter results (S2,3,6,7,10 and 11). Box plots were created by element
373 and by site with mean values and a notch narrowing around median values (ggplot 2
374 in R). Differences between animal sizes were assessed using histograms of
375 osteometric distributions by LSI values grouped firstly by site (e.g. Fig.5 and Fig.6)
376 and secondly by chronology (IA and LBA), (e.g. Figs.7, 11 and 15) with bioclimate
377 differentiated each time by colour. The statistical significance in the observed
378 differences between sites and populations was assessed using Kruskal-Wallis test
379 conducted in R. Finally, a kernel density plot was used to compare IA and LBA
380 populations, showing the probability density of animal size distribution in each
381 population (e.g. Figs.8, 12 and 16). All these analyses were conducted independently
382 for LSI length and width values.

383

384 **4. Results: Livestock management**

4.1. Husbandry pattern

386 Domestic ungulates represent the main meat source for LBA and IA societies in the
387 northern Levant. The Iron Age animal economy depended mainly on four livestock
388 taxa. Wild species contribute marginally to the diet with NISP frequency less than 5%
389 for most sites, except for Qatna (11%), Tweini (7%), and Kamid el Loz (6%). Wild
390 species consist mostly of fallow deer, gazelle, wild boars and a good spectrum of wild
391 Carnivora (foxes, mustelids, wolves, leopards, bears). In addition, hippopotamus
392 bones were identified in Tweini, while elephant ivory was used for manufacturing
393 artefacts at Sidon (Chahoud, 2022). Caprines are the most exploited domestic
394 mammals on all sites in the northern Levant, followed by cattle and complemented by
395 swine (Fig. 2 and S.1). Other mammals are less frequent and include horses,
396 donkeys and dogs, whereas a few Iron Age camelid bones are attested for the first
397 time in the northern part of the studied area (e.g., Afis and Qatna). For all IA sites,
398 sheep and goats are the most frequent animals with more than 50% of the NISP (Fig.
399 2 and S.1.a, S.1.b). A significant difference between sites is observed, especially in
400 the exploitation of cattle and pigs according to geographic position, rather than the
401 type of settlement (Correspondence analyses S.1). Indeed, the frequency of cattle
402 fluctuates between 20% and 40% of the NISP on all sites, except at Tuqan (10%).
403 Furthermore, pig breeding is relatively widespread in the hinterland, especially in the
404 northern sites (e.g., Ain Dara and Gindaris), while it is less common on coastal sites
405 (Ras Ibn Hani, Kazel, Tweini, Sidon and El Burak), (Fig. 2 and S.1.a, S.1.b). Overall,
406 coastal sites show very similar husbandry practices based on sheep and cattle, while
407 hinterland sites are more diversified in terms of cattle and pig consumption. No clear
408 correlation is observed between livestock frequency and settlement types
409 (Correspondence analyses S.1.b). On the contrary, a shift from caprines and cattle
410 towards more pigs is clear for the two northernmost sites (Ain Dar and Gindaris) and
411 the hinterland sites (Fig. 2 and S.1.a, S.1.b). The sheep/goat ratio (Fig. 4) shows that
412 sheep are more frequent than goats for the IA sites. Nevertheless, goats are still
413 frequent in some assemblages as they represent about half of the identified caprines
414 at Ain Dara (northern site), Sidon, Kami del-Loz and El Burak (southern site of the
415 studied area). Unlike the IA sites, the husbandry pattern for the Late Bronze Age
416 settlements is almost exclusively based on sheep, goat and cattle exploitation, except
417 for the northernmost site of Alalakh, which probably follows the pattern observed for
418 the Anatolian sites with more pigs in the economy (Fig. 3 and S.1.c; see discussion in
419 Slim et al., 2020; Slim and Çakırlar, 2022 in this volume). Significant differences are
420 attested between coastal and hinterland sites. During the LBA, sheep and goats
421 represent more than 65% of the NISP, except for Alalakh (in Turkey) and Kazel (in a
422 temple context). The clear difference between the two geographical regions is
423 marked by the importance of cattle and the absence of pigs on the coast, while the
424 latter is attested in hinterland sites, albeit in small proportions (less than 5% of NISP),
425 (Fig. 3 and S.1. c).

426 Therefore, Iron Age husbandry practices can be defined as mixed exploitations
427 based on the four domestic livestock (sheep, goats, cattle, and pigs). In contrast, the
428 LBA pattern shows more specialised caprines and cattle exploitation, where pig
429 husbandry plays no economic role. Progressively, from the LBA to the IA, we observe
430 a continuous pattern for husbandry practices if we consider the trajectory in each
431 geographical region; coast and hinterland. Nevertheless, the reintroduction of pigs
432 marks a striking shift, especially on hinterland sites over the exploitation of sheep and
433 goats. Pigs are entirely or nearly absent from coastal sites (Ougarit, Tweini, Kazel,
434 and Sidon) in the LBA and IA, sheep and goats decrease slightly (on average 10%)
435 in the IA, whereas cattle play a more constant role in the LBA and IA economy.

436 **4.2. Livestock biometry**

437 **4.2.1. Sheep**

438 The analysis of sheep biometry was based on 707 unique bone measurements (158
439 for length and 549 for width) for IA sites and 1105 for LBA sites (346 for length and
440 759 for width). The comparison of LSI values by anatomical element shows that
441 archaeological sheep bones do not present any allometry in comparison with the
442 standard used as a reference (S.2 & S.3). Most of the archaeological bone remains
443 are fragmented, and thus more width measurements were taken for these remains.
444 The size differences between anatomical elements reflect bone proportions, which
445 can vary between anatomical parts and between breeds (Davis, 1996). Therefore, we
446 compared the distribution of the LSI by element to ensure that changes in animal
447 sizes were not due to the allometry of an abnormal element. According to the mean
448 and data distribution, sheep LSI values of the calcaneus and astragalus lengths tend
449 to be larger than the radius and metacarpus lengths (Kruskal-Wallis chi-squared =
450 5.441, df = 4, p-value = 0.245, S.2). Furthermore, LSI astragalus widths are similar to
451 metacarpus and metatarsus values but slightly larger than the width of limbs (radius,
452 humerus, tibia and especially femur, Kruskal-Wallis: chi-squared = 26.2, df = 6, p-
453 value = 0.0002044, S3). Both the length and width LSI values of the metacarpus tend
454 to be slightly smaller than those of the metatarsus. In addition, upper limbs tend to be
455 slightly larger than lower limbs for width LSI values (related to the presence of horns,
456 for example). These distributions show that foot bones contribute slightly to the large
457 and robust size of IA sheep compared to limb parts (S.2 and S.3).

458 Based on LSI means by site assemblage, Iron Age sheep are larger and
459 proportionally slanderer than the reference standard (Fig.5, S.4, S.5 and S.14). The
460 dispersion of LSI values at Tweini is particularly widespread compared to the other
461 sites. The large set of length data available from Tweini shows the presence of two
462 main groups of sheep sizes, also attested on several sites. LSI means are quite
463 diverse among assemblages and sheep size is significantly different between IA sites
464 (Length: Kruskal-Wallis chi-squared = 28.931, df = 8, p-value = 0.000326 & width:
465 Kruskal-Wallis chi-squared = 89.375, df = 9, p-value = 2.173e15; Fig. 5, S.4, S.5, and

466 S.14). Two sites located in the northern part of the coastal region (Tweini and Ras
467 Ibn Hani) have the lowest LSI values and means for both width and length, while
468 Sidon (coastal site) and the hinterland sites have higher LSI values and means. It can
469 be noted that the single width value at Tell Kazel falls in the lower size distribution of
470 sheep. Meanwhile, the LSI values of sheep from the Late Bronze Age sites are also
471 higher than those of the standard (Fig. 6). The wide dispersion of values is particularly
472 marked at Kamid el Loz, Nebi Mend, and Tweini. The Kazel site has the smallest
473 mean for length and width LSI values.

474 The comparison of sheep LSI values between the two periods (LBA and IA)
475 indicates, on most sites, a decrease in Iron Age length and width (Differences of LSI
476 value between IA and LBA for Length: $t = 0.118$ $p = 0.90$; Width: $t = 0.64$, $p = 0.52$;
477 Fig. 7). This is particularly clear at sites for which there are sufficient data for both
478 periods (Nebi Mend, Sidon, Tweini, Qatna, Ras Shamra, and Ras Ibn Hani). On the
479 contrary, the available LSI values for both periods for the two most southern sites,
480 Sidon (coastal) and Kamid el-Loz (hinterland), tend to be higher for the Iron Age (Fig.
481 7). Furthermore, the density plots of length and width values by period show
482 multimodal distributions with several density peaks distributed differently by period
483 (Fig. 7). The dispersion of values is more pronounced in the LBA than in the IA. The
484 multimodal distributions suggest the presence of different types of sheep. Based on
485 size values, three types of sheep appear in the Iron Age. This difference is not only
486 generated by the sexual dimorphism of sheep but also indicates presence of sheep
487 types of different sizes. The presence of different sheep sizes is also suggested by
488 the strong dispersion of values in the Late Bronze Age, which can be interpreted as
489 the effect of greater sheep type heterogeneity, which slightly decreased in the Iron
490 Age (Fig. 8). The synthesis of data by period and geographical regions shows that
491 the size (length) and robustness (width) of Iron Age sheep are on average lower than
492 those of LBA sheep (Fig. 7). The lowest values are represented in coastal
493 assemblages. This is visible for size values in both the Late Bronze and Iron Ages.
494 On the other hand, for robustness, the low values are more clearly marked on the
495 coast in the Iron Age than in the Late Bronze Age. Therefore, according to the
496 proportions of size and robustness, two ovine phenotypes are clearly shown on the
497 coastal sites of the Iron Age. Sheep at the coastal sites appear to fall into several
498 types given the dispersion of values that overlap with the values of assemblages from
499 hinterland sites (e.g. Albesso, 2018). In other words, the morphometric diversity of
500 Iron Age sheep is greater at coastal sites than at inland sites

501 **4.2.2. Goat**

502 The analysis of goat biometry was based on 299 unique bone measurements for IA
503 sites (Length: 72, Width: 227) and 511 for LBA sites (Length: 135, Width: 376);
504 (S.14). Comparison of LSI values by anatomical element shows that the
505 archaeological goats are smaller than the standard used as a comparative reference
506 (S.6, S.7). The comparison of LSI values by anatomical element shows that

507 archaeological goats are smaller than the standard used as a comparative reference.
508 From the perspective of proportions of anatomical parts, LSI values for calcaneus
509 length tend to be lower than those for other bones, while average metacarpus length
510 values tend to be higher than metatarsus length. On average, the robustness values
511 tend to be lower for the radius and metacarpus than for the other skeletal parts. On
512 the other hand, the astragalus provides the highest values.

513 Length and width values for Iron Age assemblages do not show significant
514 differences between assemblages, except at Tweini, where average length and width
515 values are lower than for the other assemblages (Fig.9; S.8 and S.9). The Late
516 Bronze Age assemblages show fairly variable mean values from one site to another.
517 The width values at Sidon and Ugarit are particularly low (Fig.10). The width values
518 at Sidon and Ugarit are particularly low. At Nebi Mend, values are distributed in two
519 groups: the higher values relate most probably to the presence of feral, ibex, or wild
520 goats (Grigson et al., 2015). In addition, high values are also attested at Kamid el
521 Loz.

522 The synthesis of data by period and geographical regions does not indicate major
523 differences in goat size and robustness between coastal and hinterland sites
524 (Differences of LSI value between IA and LBA for Length: $t = 5.410$ $p < 0.0001$;
525 Width: $t = 4.841$, $P < 0.0001$; Fig. 11). The coastal/hinterland histograms overlap for
526 both periods. Nevertheless, during the Iron Age, the lowest values appear on the
527 coast. The highest values observed in the Late Bronze Age, which probably
528 correspond to wild individuals, are only found at hinterland sites (Fig. 12). From the
529 density plots of LSI length and width values by period, the mean Iron Age value is
530 lower than the Late Bronze Age value. Two peaks emerge in the Iron Age for the
531 length and width of goats. Given the low overall dispersion of values and the
532 sharpness of the two peaks, it is likely that they represent males and females. In
533 contrast, the Late Bronze Age density peaks are quite indistinct and values are
534 widely dispersed. This shows greater variability in goat types and the presence of
535 wild individuals in the assemblages. Therefore, the sizes of goats tend to be similar in
536 LBA and IA sites.

537 **3.2.3. Cattle**

538 Analysis of cattle biometry was based on 1104 unique bone measurements for IA
539 sites (Length: 320, Width: 784) and 995 for LBA sites (Length: 316, Width: 679);
540 (S.14). However, some skeletal elements, in particular the long bones (metapodials,
541 humerus, radius, and tibia), show higher variability in width LSI values compared to
542 the feet (astragalus and phalanx), (Length: Kruskal-Wallis chi-squared = 93.661, $df =$
543 179 , p -value = 1; Width: Kruskal-Wallis chi-squared = 751.87, $df = 433$, p -value
544 $< 2.2e-16$; S.11, and S.12). This could be explained by sexual dimorphism, castration
545 or the presence of different cattle types (zebu and taurine cattle). Prolonged growth
546 due to castration leads to late fusing and the bones of castrated animals are thus
547 slenderer than those of non-castrated animals (Pöllath and Peters, 2005). The Iron

548 Age assemblage show fairly close LSI mean values for the different assemblages,
549 except Ras Ibn Hani, where the means are lower, and Kamid el Loz, where the
550 means are higher (Length: Kruskal-Wallis chi-squared = 93.661, df = 179, p-value = 1
551 & Width: Kruskal-Wallis chi-squared = 751.87, df = 433, pvalue <2.2e-16; Fig. 13). At
552 several sites, robustness values are widely dispersed (e.g., Gindaris, Qatna and
553 Tweini). Some very high values fall outside the general distribution, as is clear at
554 Tweini and Qatna. They probably correspond to aurochs (S.12 and S.13).

555 In the Late Bronze Age, the assemblages show quite similar dispersions and means
556 to those of the Iron Age (Length: Kruskal-Wallis chisquared = 233.51, df = 190, p-
557 value = 0.01722 & Width: Kruskal-Wallis chi-squared = 531.45, df = 408, p-value =
558 3.561e-05; Fig. 14). The lowest average LSI values are at Kazel and Sidon (coastal
559 sites) while the highest is at Kamid el Loz (hinterland). Particularly low values outside
560 the general dispersion values are noted at coastal sites (Kazel, Sidon, and Ugarit),
561 but are not observed at hinterland sites.

562 A comparison of the LSI data for cattle between the coast and the hinterland does not
563 show major differences between the two geographical regions (Differences of LSI
564 value between IA and LBA for length: $t = 3.456$ $p = 0.0006$; width: $t = 4.709$, $P <$
565 0.0001 ; Fig. 15). Nevertheless, the lowest LSI values of robustness are found on the
566 coast. On the density graph (Fig. 16), the means for the Iron Age are lower than
567 those for the Late Bronze. Values are concentrated in several peaks for both periods.
568 In the Late Bronze Age, size values are distributed in four major density peaks and
569 robustness values in three weakly represented peaks. In the Iron Age, three density
570 peaks are observed for size and robustness, with a widespread dispersion. These
571 peaks most certainly result from the combination of males and females and the
572 presence of castrated animals as well as the presence of several types of cattle such
573 as taurus and zebu forms (Clason, 1978; Bökönyi, 1990; Albesso, 2018; Verdugo et
574 al., 2019). The highest values are certainly evidenced by wild cattle. Therefore, the
575 size of cattle tends to be smaller for Iron Age sites in comparison with LBA sites,
576 especially for the coastal sites.

577

578 **4.2.4. Pigs**

579 The pig was the most underrepresented species in biometric data due to the scarce
580 quantity of measurable pig elements in the assemblages(82 measurements). Hence,
581 only robustness measurements were used for comparisons between assemblages
582 (Fig. 17). The lack of data does not allow for a comparative analysis between the
583 Late Bronze and Iron Ages. Pig values at Tweini and Gindaris show a similar
584 distribution, while the higher values indicate the presence of wild boar. The lower
585 values correspond to domestic pigs while the higher values show the occurrence of
586 wild boars in the assemblages.

588 **5. Discussion**

589 The analyses of dataset presented above show clearly that the interpretations of
590 results are closely affected by the number of measurable bones and the number of
591 identified specimens. The economy of the Iron Age in the northern Levant is based
592 on mixed husbandry of sheep, goats, cattle, and pigs, while the more specialised
593 LBA economy is based on sheep/goats and cattle. Livestock management involves
594 more sheep than goats in Iron Age sites while the latter is more important in LBA
595 settlements. Cattle exploitation is consistent in LBA and IA sites, whereas a clear
596 reintroduction of pigs is evidenced for Iron Age settlements, especially in hinterland
597 sites. As for biometric size, we note an overall increase in the size of sheep with a
598 wide range of diversity on the coast during the Iron Age. Goat size, on the other
599 hand, shows no clear variability between the LBA and IA. As for cattle, the
600 occurrence of two categories (small/large, robust/ slender) is probably related to
601 sexual dimorphism or the presence of hybrid, castrated and/or zebu individuals in the
602 assemblages, mainly for the LBA (see discussion below). For the Iron Age, this
603 division is slightly less clear. Finally, the biometric data for pigs are too scarce to
604 reveal any clear changes.

605

606 **5.1. Relation between climate aridity and husbandry pattern**

607 Social and environmental changes between the end of the second and the beginning
608 of the first millennia BCE, i.e., between the Late Bronze and Iron Ages, have
609 important repercussions on animal husbandry and domestic fauna. The livestock
610 economy of Late Bronze Age cities is largely based on the exploitation of caprines
611 and cattle (Vila and Gourichon, 2007; Vila, 2008; Chahoud, 2013, 2015). Livestock
612 husbandry is part of larger economic systems governed at a larger scale, either at the
613 state level or at the city level, to manage the supply of meat, milk products, and raw
614 materials (wool, skin, hair, and horn), (e.g. Greenfield, 2010). On the other hand, pigs
615 are rare and their exploitation does not play any role in this period for reasons
616 discussed by different researchers, which may be ecological, economic and political
617 (e.g. (Hesse, 1990; Hesse and Wapnish, 1998; Zeder, 1998; Vila, 2006a)). However,
618 the scarcity of pigs when considering the sites of Qatna and Kamid el Loz does not
619 seem to be related to environmental conditions but rather to the economic
620 preferences of these urban centres (Vila, 2006a). Indeed at the end of the
621 Chalcolithic and during the Bronze Age, due to the development of the textile industry
622 in the Near East and the ever-increasing demand for the production of woolly fleece
623 in urban centres, sheep husbandry became the main focus of the animal economy
624 (Vila and Chahoud, 2019). The collapse of Late Bronze Age economic systems due

625 to conflicts and invasions, the destruction of large cities and the fall of regional centres
626 of great economic and commercial importance necessarily implied a change of scale
627 in the organisation of the livestock economy.

628 **5.2. Social changes and husbandry**

629 In the Iron Age, the animal economy and the meat diet were based on mixed
630 breeding with the exploitation of the four domestic taxa: sheep, goats, cattle, and
631 pigs. This type of economy, which incorporates pigs to a greater extent, could mark
632 the rural character of early Iron Age settlements. Indeed, the latter developed without
633 a central regional system of control and probably reflects new incoming cultural
634 influences from the eastern Aegean and Cyprus, or an influence from northern Syria
635 and Mesopotamia for the later IA phase. By way of comparison, it should be noted
636 that in northern Syria and Mesopotamia, Bronze Age pig rearing is proven to be
637 unrelated to institutional control and reflects rather an alternative animal economy
638 (McCorriston, 1997; Price et al., 2017); cf. the textual sources (Lion and
639 Michel, 2006). The analysis of the presence of pigs in the southern Levant shows that
640 in the Iron Age I, urban sites (Philistines) are characterised by a strong presence of
641 pigs and that pig consumption subsequently increases in the northern part of the
642 southern Levant (IA IIB) and disappears in the southern part, which is related to
643 cultural abstentions from pig consumption (Sapir-Hen et al., 2013). Thus, in the
644 southern Levant, the pig does not appear to be linked to rural settlements. The
645 presence of the pig at Iron Age sites in the northern Levant could also be related to
646 the arrival of new populations by sea, as discussed for the southern Levant, with the
647 hypothesis of the introduction of new populations, such as the Philistines with their
648 dietary and husbandry habits from the twelfth century BCE onwards (Hesse, 1986,
649 1990; Lev-Tov, 2000). Recent DNA analyses show that pigs of exogenous origin
650 became predominant in the southern Levant in the Iron Age while pigs in earlier
651 periods were of local origin (Meiri et al., 2013). Indeed, pig breeding in the Late
652 Bronze Age is practised, albeit on a variable scale depending on the site, in northern
653 Syria and south-eastern Anatolia. This may be due to cultural influences from
654 northern Syria (Cavallo, 2002; Vila, 2006b; Becker, 2008) and in south eastern
655 Anatolia (Slim et al., 2020) introduced by the Assyrian and Hittite populations. Pig
656 breeding in the northern Levant during the Iron Age seems to be more of an enduring
657 tradition than the result of acculturation.

658

659 **5.3. Changes in livestock management**

660 From a morphological point of view, a major change in the domestic animal population
661 appears during the Iron Age. There is a general reduction in the size of sheep, goats,
662 and cattle (not analysed for the pig due to the lack of data) compared to the previous
663 period. The fact that this reduction is observed in three different taxa is enigmatic.

664 Several factors could have affected animal anatomy. A first factor could be the
665 deteriorating climatic conditions affecting the Near East with an episode of severe
666 aridity in the early Iron Age (Riehl et al., 2014; Langgut et al., 2015) that could have
667 impacted animal size due to a more arid general environment and less rich pastures.
668 Nevertheless, large-sized animals are still present in most Iron Age settlements. A
669 second factor could be related to the change in animal husbandry, management and
670 maintenance. The practice of fattening or feeding domestic and wild animals with
671 barley is common and has been attested in early periods. In Mesopotamia, it is
672 attested in the third millennium, as testified in written sources (Ellison, 1978). This
673 practice of fattening continues into the Neo-Assyrian period. It is possible that certain
674 animal husbandry practices changed following the dismantling of the socio-political
675 structures of the cities and states of the Late Bronze Age, and that domestic animals
676 may have suffered from malnutrition. Finally, the contribution of new domestic
677 'strains', as has been demonstrated via ancient DNA for the pig, could be a
678 satisfactory answer to this situation at this stage of research. Indeed, the smaller-
679 sized animals observed, especially sheep, are found in coastal site assemblages.
680 The decrease in size of the three domestic taxa between the Bronze and Iron Age
681 periods is less clear at hinterland sites. The small-sized specimens from the coast
682 that are not found at hinterland sites could result from the arrival of allochthonous
683 animals by sea. This seems obvious for sheep and explains the presence of greater
684 phenotypic variation in size and robustness on the coast than inland. Depending on
685 their origin, certain sheep breeds may have had difficulty adapting to a new
686 environment and different vegetation and stressful climatic constraints. Thus, this
687 may explain the existence of different types of sheep on the coast and the hinterland
688 of the Iron Age. On the other hand, there is no difference between the two
689 geographical regions for goats and cattle. The goat data seem to reflect sexual
690 dimorphism rather than the presence of different types at the sites. The wild goat (*C.*
691 *ibex* or *C. aegagrus*) is attested at Nebi Mend, near Lebanon and Anti-Lebanon
692 Mountains (Wasse, 2001; Hassan et al., 2018). The organisation of data for cattle
693 into several groups in the Late Bronze and Iron Ages may result from several factors:
694 sexual dimorphism, the practice of castration, the existence of several cattle breeds,
695 and the presence of the taurus type (*Bos taurus*), the zebu type (*Bos indicus*), and
696 their hybrids. The zebu is attested osteologically (bifid vertebrae) and
697 archaeologically (iconography) in Mesopotamia around 1700-1600 BCE (Matthews,
698 2002). The earliest identification of the zebu in the Levant (Jordan) dates back to the
699 Late Bronze/Early Iron Age (Clason, 1978). At Kamid el Loz, sexual dimorphism
700 between males and females does not seem to be significant, according to the author
701 of the study (B"ok"onyi, 1990). In contrast, the zebu was identified at the site based
702 on gracile feet and the presence of bifid vertebrae for the LBA. In addition, it occurs
703 at Nebi Mend in the Late Bronze Age (Grigson, 2015). At Kamid el Loz, the
704 hypothesis of the presence of three distinct types or breeds at these sites has been
705 suggested: the zebu (*Bos cf. indicus*), a large bovine, and a small bovine of the
706 humplless type (B"ok"onyi, 1990). At Ras Shamra (LBA), the existence of three
707 bovine types had also been discussed (Vila, 2008; Chahoud and Vila, 2017), and

708 interpreted as the occurrence of small-sized cows, average-sized oxen and castrated
709 bulls of larger size. It is known from textual sources that one type of cattle was raised
710 for consumption and another type for ploughing work (Yon, 1997). The regional
711 synthesis of metric data shows continuity for the IA and points to the probable
712 presence of more than three groups of cattle. In addition, aurochs were still present
713 and hunted in the Iron Age.

714 6. Conclusion

715 This regional and diachronic analysis of the Iron Age and Late Bronze Age faunal
716 assemblages reveals that variability in animal husbandry and livestock management
717 in the northern Levant are related to climatic variations and social and political
718 changes. As shown through architecture, cultural material and social patterns,
719 continuity and new traditions are also demonstrated in the sphere of animal
720 management. Despite small sets of bone assemblages and measurement data, the
721 combined LSI analyses by period and geographic regions generate new results. The
722 analyses corroborate previous observations, such as the decline in the size of
723 domestic animals during the Iron Age, while revealing through comparative study that
724 this decline in size is a widespread phenomenon and that it started earlier than the
725 Late Bronze Age. The diversity of bovine forms in the Late Bronze Age as well as in
726 the Iron Age is confirmed. Finally, the innovative result of the LSI analyses conducted
727 on these Iron Age assemblages is the identification of differences between coastal
728 and hinterland sheep types, with the presence of small-sized sheep on coastal sites
729 suggesting the existence of allochthonous sheep populations and animal trade by
730 boat in large centres. At the beginning of the Iron Age, coastal cities are the most
731 influenced by the changes that occurred (urban to rural settlement). Afterwards, in
732 the IA II and IA III, hinterland sites became parts of kingdoms that progressively were
733 incorporated into the Assyrian empire while coastal sites functioned as trading ports
734 and remained as independent city-states that paid tribute to the Assyrian empire
735 (Sader, 2013; Steiner, 2013). With the changes occurring in the first millennium BCE,
736 we would expect that the economy based on animal husbandry has been affected.
737 The hypothesis noted in the culture material is that of a shift to a rural economy in IA
738 I, and from a state economy to a large-scale open trade economy in IA II-III.
739 Therefore, this observation is confirmed by the change in animal exploitation between
740 the large centres of LBA and the shift to a rural economy at the beginning of the Iron
741 Age. This would be explained for example by the use of mixed economy attested in
742 rural settlements or specialised economy attested in large centres. Probably the
743 independent city-states of different kingdoms of the Levant had a different pattern of
744 the animal economy and a variety of animal types (sizes, age.) especially due to the
745 increasing trade. Meanwhile, the influence of the incoming power of the Assyrians in
746 the Levant might have had a certain power to control animal production and the
747 economy. Therefore, it could explain a centralised similar economy and animal
748 management in the region during the IA II-III. Furthermore, given the climatic

749 changes throughout the transition between the Bronze and Iron Ages, it is expected
750 that livestock management to have adapted to this increased aridity in terms of
751 animal breeding practices. And in Iron Age in general, with the variability of social
752 and political patterns, livestock management would be expected to be different
753 between rural/urban and/or large/small centres. These challenges and adaptation to
754 both cultural and climate changes would have eventually affected the subsistence
755 economy and animal sizes. Certain taxa were not exploited in large centres. Finally, a
756 similar discussion on husbandry patterns is needed for the surrounding regions (e.g.
757 S Anatolia, N Euphrates valley of Mesopotamia, southern Levant) to have a large-
758 scale analysis of the animal economy. The climatic changes often invoked as one of
759 the causes of the collapse at this pivotal transition only have a slight impact on the
760 exploitation of domestic animals. The analyses carried out here identified different
761 phenotypes (size, slender) of domestic animals for Late Bronze and Iron Age
762 settlements. Sheep, goat, and cattle types in coastal and hinterland settlements
763 should be assessed with a large dataset with a better-defined chronology to
764 understand their heterogeneity. More advanced research is needed in extensive
765 regions of the Near East to reconstruct these changes.

766

767 [Author contributions](#)

768 JC and EV contributed equally to the study of faunal remains, data analyses and the
769 writing of the paper. JC performed the computations and the analyses in R and
770 PAST.MA Contributed to the dataset of faunal remains and measurements of the
771 Tweini site.

772 [Data availability](#)

773 The data are presented in supplementary file by mean values of Length and Width of
774 Log Ratios for measurements and total NISP for faunal remains.

775 [Declaration of competing interest](#)

776 The authors declare that they have no known competing financial interests or personal relationships
777 that could have appeared to influence the work reported in this paper.

779 **Acknowledgements**

780 This work was made possible by collaboration with the team of ARC starting Grant
 781 ZoomWest. We wish to thank Silvia Valenzuela-Lamas; Angela Trentacoste and
 782 Ariadna Nieto-Espinet for their help with the use of the package *zoolog*. Part of the
 783 analysis was funded by the French National Research Agency (EvoSheep- ANR-17-
 784 CE27-0004). The authors thank Sofian Bouzid (Archéorient, CNRS-UMR 5133) for
 785 his help and discussion on statistical analysis. Finally, we are grateful to C. Grigson
 786 for accepting to share her dataset of unpublished measurements with us.

787

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1064 **Figures**

1065 **Figure 1:** Map of the Northern Levant with locations of studied sites in different bioclimates
 1066 (Mediterranean zone-light blue: Coastal plain-blue: Hills and piedmonts; Mountain zone-pink: Humid
 1067 mountains with forests-purple: Arid mountains of eastern taurus-brown: Arid mountains of Anti-
 1068 Lebanon and Syrian steppe; Steppe zone-light green: hills and mounts-dark green: Plateau and zone
 1069 of arid cereal culture; arid steppe-light red: Internal margin of humid zone; sub-desert zone-light
 1070 orange: Syrian desert; Desert zone-yellow: hyper arid areas; modified after ASPRO), (Hours et al.,
 1071 1994)).

1072 **Figure 2:** Iron Age livestock: NISP frequencies for the main domesticated ungulates in the Northern
1073 Levant by bioclimate from the north to the south (Test for equal means: One-way ANOVA: Between
1074 groups: Between groups Sum of sqrs/df/Mean
1075 square/F/p(same)1.22633E07/2/6.13166E06/2.406/0.1035; Within groups: Sum of sq/ df/Mean
1076 Square 9.94061E07/39/2.54887E06; Permutation p (n=99999); Total: Sum of squares/
1077 df/p(same):1.11669E08/df41/0.05651; Levene's test, from medians/p (same):0.).

1078 **Figure 3:** Late Bronze Age livestock: NISP frequencies for the main domesticated ungulates in the
1079 Northern Levant by bioclimate from the north to the south (Test for equal means without data from
1080 Alalakh: Between groups Sum of sqrs/df/Mean
1081 square/F/p(same):4.8298E07/df:2/2.4149E07/F:6.843/p:0.005148; Within groups: Sum of sq/
1082 df/Mean Square: 7.41059E07/ 21/3.52885E06 /Permutation p (n=99999); Total: Sum of squares/
1083 df/p(same): 1.22404E08/23/p:0.00289. Levene's test for homogeneity of variance, from means, p
1084 (same):0.0002586; Levene's test, from medians, p (same): 0.0007479).

1085 **Figure 4:** Frequency of sheep vs goats for the Iron Age sites (NISP).

1086 **Figure 5:** Histogram of distribution of LSI values Length and Width by Iron Age assemblages for Sheep
1087 (dashed lines indicates the mean; N. of variables: 158 for length and 549 for width; Length: Kruskal-
1088 Wallis chi-squared = 28.931, df = 8, p-value = 0.000326 & width: Kruskal-Wallis chi-squared = 89.375,
1089 df = 9, p-value = 2.173e-15).

1090
1091 **Figure 6:** Histogram of distribution of LSI values Length and Width by Late Bronze Age assemblages
1092 for Sheep (dashed lines indicate the mean; N. of variables: 346 for length and 759 for width; Length:
1093 Kruskal-Wallis chi-squared = 262, df = 218, p-value = 0.02213; Width: Kruskal-Wallis chi-squared =
1094 548.49, df = 460, p-value = 0.002798).

1095 **Figure 7:** Histogram of Distribution of Length and Width LSI values by periods and bioclimatic regions
1096 for Sheep. (dashed lines indicate the mean). Period/mean Length/n: Iron Age=0.05767360/158; Late
1097 Bronze=0.07372382/346 & Period/mean Width/n: Iron Age=0.04741113/549; Late
1098 Bronze=0.06183522/759. Differences of LSI value between IA and LBA for Length : t=-0.118 p=0.90;
1099 Width: t= 0.64, p=0.52).

1100 **Figure 8:** Density graph of the Length and Width LSI values by periods for Sheep (dashed lines
1101 indicate the mean).

1102 **Figure 9:** Histogram of distribution of LSI values Length and Width by Iron Age assemblages for Goat
1103 (dashed lines indicate the mean ; N. of variables: Length: 72, Width: 227; Length: Kruskal-Wallis chi-
1104 squared = 71, df = 62, p-value =0.2029; Width: Kruskal-Wallis chi-squared = 226, df = 185, p-value
1105 =0.02139).

1106 **Figure 10:** Histogram of distribution of LSI values Length and Width by Late Bronze Age assemblages
1107 for Goat (dashed lines indicate the mean ; N. of variables: Length 135, Width 376; Length: Kruskal-
1108 Wallis chi-squared = 92.087, df = 87, p-value = 0.3341; Width: Kruskal-Wallis chi-squared = 301.1, df =
1109 249, p-value = 0.01326).

1110 **Figure 11:** Histogram of Distribution of Length and Width LSI values by periods and bioclimatic
1111 regions for Goat. (dashed lines indicate the mean; Period/mean Length/n: Iron Age=-0.04677732/72;
1112 Late Bronze=-0.02648837/135 & Period/mean Width/n: Iron Age=-0.06835092/227; Late Bronze=-
1113 0.04794987/376; Differences of LSI value between IA and LBA for Length : t=5.410 p< 0.0001; Width:
1114 t= 4.841, P < 0.0001).

1115 **Figure 12:** Density graph of the Length and Width LSI values by periods for Goat (dashed lines
1116 indicate the mean).

1117 **Figure 13:** Histogram of distribution of LSI values Length and Width by Iron Age assemblages for
1118 Cattle (dashed lines indicate the mean; N of variables : Length 320, Width 784; Length: Kruskal-Wallis
1119 chi-squared = 93.661, df = 179, p-value = 1 & Width: Kruskal-Wallis chi-squared = 751.87, df = 433, p-
1120 value <2.2e-16).

1121 **Figure 14:** Histogram of distribution of LSI values Length and Width by Late Bronze Age assemblages
1122 for Cattle (dashed lines indicate the mean ; N. of variables: Length 316, Width 679; Length: Kruskal-
1123 Wallis chi-squared = 233.51, df = 190, p-value =0.01722 & Width: Kruskal-Wallis chi-squared =
1124 531.45, df = 408, p-value = 3.561e-05).

1125 **Figure 15:** Histogram of Distribution of Length and Width LSI values by periods and bioclimatic
1126 regions for Cattle. (dashed lines indicate the mean; Period/mean Length/n: Iron
1127 Age=0.01079022/320; Late Bronze=0.02265326/316 & Period/mean Width/n: Iron
1128 Age=0.03049102/784; Late Bronze=0.04465096/679; Differences of LSI value between IA and LBA for
1129 Length : t=3.456 p=0.0006; Width: t= 4.709, P < 0.0001).

1130 **Figure 16:** Density graph of the Length and Width LSI values by periods for Cattle (dashed lines
1131 indicate the mean).

1132 **Figure 17:** Histogram of distribution of LSI values Width by Iron Age assemblages for Pig (dashed
1133 lines indicate the mean).

1134

1135 **Table**

1136 Table 1: Iron Age sites