STUDIA TROICA

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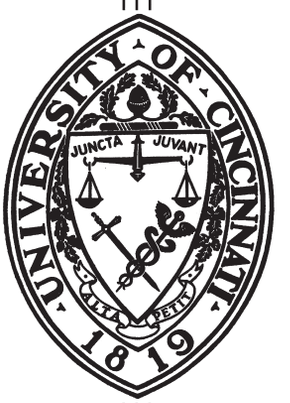

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‘MUREX’ DYE PRODUCTION AT TROİA: ASSESSMENT OF ARCHAEOMALACOLOGICAL DATA FROM OLD AND NEW EXCAVATIONS

Canan Çakırlar and Ralf Becks

Abstract

This paper presents the archaeological evidence for ‘murex’ dye production at Troia and assesses the size and character of this industry at the site, based on archaeomalacological data from old and new excavations. The amalgamated data is compared with related evidence from other Bronze Age sites in the Mediterranean basin and considered in view of the requirements of a traditional ‘murex’ dye industry. Present evidence shows that the production of purple dye at the settlement began already during the Troia VIa phase and continued until Troia VIIa. *Hexaplex trunculus* was the chief species used as raw material. We suggest that this major industry, indicated by the scale of accumulated crushed *H. trunculus* remains in the archaeological deposits, is linked to the flourishing textile industry at the site, both tied to the increasing Minoan influence in the Middle Bronze Age Aegean.

Zusammenfassung

In diesem Beitrag werden die archäologischen Nachweise für die Herstellung von Purpurfarbe aus Murex-Schnecken sowie die Art der lokalen Purpur-Industrie anhand von archäomalakologischen Daten aus den alten und neuen Ausgrabunen in Troia vorgestellt. Diese Daten werden mit den entsprechenden Belegen aus anderen bronzezeitlichen Fundorten im Mittelmeerraum verglichen und unter dem Aspekt der Voraussetzungen einer traditionellen Purpur-Industrie betrachtet. Der gegenwärtige Forschungsstand zeigt, daß die Purpur-Produktion bereits in der Troia VIa-Phase begann und bis in die Troia VIIa-Zeit andauerte. Als Rohmaterial wurde hauptsächlich die Spezies *Hexaplex trunculus* verwendet. Es wird postuliert, daß diese bedeutende Industrie – ablesbar an den großen Mengen zerbrochener Schalen von *H. trunculus* in den archäologischen Schichten – mit der florierenden Textilindustrie vor Ort verbunden ist und beide von einem zunehmenden minoischen Einfluß während der Mittleren Bronzezeit in der Ägäis ausgelöst wurden.

Introduction

Some species of carnivorous marine snails, such as the members of the family Muricidae and Thaiidae, secrete purple mucus from their hypobranchial gland.[1] The purple pigments of this substance can be extracted using a variety of techniques to produce a color-fast dye.[2] The tradition of producing dye from these marine snails, commonly known as the ‘murex’ shells, is wide-spread along the coasts of the world, from South America to Japan, including the Mediterranean.[3] In studies of Mediterranean archaeology and history, this tradition has received particular scholarly and popular attention because the phenomenon offers one of the rare inter-disciplinary opportunities to verify or appraise ancient texts with archaeological evidence.[4] Ancient authors, from Homer[5] to Pliny[6], mentioned the dye in association with trade-related prosperity and political prestige and provided detailed descriptions of production methods.[7] Biblical references to certain types of textiles associated with this dye are abundant.[8] Scholars working in the Mediterranean region have been typically associating archaeological Muricidae remains with these textual sources, in most cases presuming an integrated relationship with textile production regardless of the scale and nature of archaeological evidence related to both industries. Recently, however, new findings both on the textual and archaeological sides of the story have made it possible to draw a clearer picture of these phenomena, how they relate to each other, and what they

mean for our greater understanding of cultural developments that took place in the ancient Mediterranean.

Scholarly work around the theme of 'murex' dye production has grown enormously since 1879, when E. von Martens suggested that the Muricidae remains from Troia constituted the archaeological evidence for the dye industry mentioned in ancient texts.[9] This was the first time in Mediterranean archaeology that mollusk remains encountered among the remains of ancient settlements were associated with this dye industry. The discovery of several other sites with Muricidae remains and a great deal of scientific and popular literature written on the subject followed von Marten's initial observation. Many scholars experimented with ancient descriptions of production methods to reproduce the dye and investigated its chemistry,[10] whereas others continuously showed archaeological Muricidae remains of the Mediterranean basin as evidence for ancient dye production.[11] Presently, more and more attention is paid to critically measuring the scale of production at various sites where Muricidae remains have been found, instead of vague descriptions of the archaeological evidence leading to straightforward results.[12] In addition to new findings in textual and archaeological scholarship, a belated awareness of the fact that Muricidae flesh can be used as a food resource for humans and as fishing bait, in other words a better understanding of the malacological and anthropological qualities of these species, seems to have led to more critical assessments of the evidence.

In the light of recent scholarship, it is also necessary to re-evaluate the previous *a priori* perceptions of the Trojan 'murex' dye industry. The aim of the present paper is to discuss the size and character of this industry at the Bronze Age settlement, based on the archaeomalacological data from old and new excavations. The careful examination of amalgamated evidence presented here leads to a more accurate assessment of the nature of dye production at Troia.

Classification, biology, and ecology of Mediterranean 'murex shells'

For an accurate scientific evaluation of the evidence for ancient Mediterranean murex dye industry, understanding the relevant biological and ecological characteristics of the animals used for the production of this dye is essential.

Marine snails commonly known as the 'murex' shells are represented by two families in the Mediterranean: the Muricidae and the Thaiidae. *Hexaplex trunculus*,[13] the common murex snail, and *Bolinus brandaris*, the spiny murex snail, are members of the Muricidae family, whereas *Purpura haemastoma* is the most common and probably the only endemic species of the Thaiidae present in the Mediterranean waters.[14]

A discussion on the population density and habitat of these species is relevant to the archaeomalacological interpretations in this paper. The archaeomalacological deposits representing murex dye production are overwhelmingly dominated by shells of the common murex.[15] As with most archaeobiological research, we have to ask whether this situation reflects a specific preference for this species or the choice for common murex snails is a consequence of an adaptation to environmental conditions.

As the common name suggests, *H. trunculus* is more common than its sibling *B. brandaris*. This also appears to be the case in Turkish coastal waters.[16] On the other hand, we should mention that since the spiny murex snail tends to live in waters deeper than the common murex snail, the frequency of the common murex may only be a reflection of human observation and not the actual density of the populations. *B. brandaris* lives on a variety of substrates, including coarse, sandy, or muddy areas and sometimes on rocky bottoms in the circumlittoral zone, i. e., offshore in deeper areas of the sea.[17] It is very likely that its habitat makes this species difficult to obtain. Alternatively, it is also reasonable to hypothesize that the spiny murex snail's relative scarcity is a true indication of its lower reproductive rate and hence thinner population density, since the animal's shell morphology suggests a closer phylogenetic relationship to the Muricids of warmer tropical waters. However, since all this still needs to be subject to systematic scientific research, this discussion cannot go beyond speculation. In addition, modern malacological research has also not yet demonstrated whether *Purpura haemastoma*, also a coastal dweller, is as common as the common murex snail or whether it occurs in lower densities.

The common murex snail dwells on sandy and rocky bottoms in shallow bays, marine and brackish lagoons, and occasionally deeper in wave-exposed coasts of the infralittoral zone.[18] But colonies generally prefer quiescent waters. Small communities of *H. trunculus*, consisting of 10–15 individuals can still be seen in the shallow and tranquil areas of the coasts of the Troad. *B. brandaris,* on the other hand, seems more apt to life in fully marine environments in deeper waters with little or no influence from sources of freshwater. Muricidae are carnivorous animals that prey on a variety of gastropods and bivalves by means of drilling into their shells.[19] Although mainly predatory animals, they also scavenge when they have the opportunity to do so. This explains why they are common at the bottoms of fishing harbors.[20] *H. trunculus*' solid shell consists of a triangular spire and a short body whorl, both with rough spiny sculpture. Individuals reach

a maximum height of 83 mm.[21] Shell color is a grayish green, striped with purple, especially visible on the inner side.

P. haemastoma only slightly differs from *H. trunculus* in terms of ecology, habits and appearance. In contrast to *H. trunculus* populations, *P. haemastoma* communities inhabit rocky bottoms only. This ecological characteristic is probably the best explanation for the reason why they appear in significantly smaller quantities in the archaeological deposits of the Mediterranean from the Middle Bronze Age onwards, although they were probably not less common than *H. trunculus* in nature. Most medium to large sized post-Middle Bronze Age coastal settlements of the Eastern Mediterranean are located at the land side of estuaries or other embayments, the benthic structure of which are covered with sandy or muddy surfaces. The shell sculpture of *P. haemastoma* is much less pronounced compared to that of *H. trunculus.*[22] Experiments have also shown that the two species produce slightly different colors.[23]

The human use of murex snails is not limited to dye production. *H. trunculus* snails, as well as other Muricids, constitute a highly-rated part of the Mediterranean seafood menu today.[24] Like some other aquatic mollusks, they are also used to prepare fishing bait. These are important ethnographic analogies to bear in mind when handling archaeological murex.

A critical overview of ‘murex’ dye production methods

As mentioned above, methods of ‘murex’ dye production have been described by ancient authors. These descriptions have been discussed in detail numerous times and the ‘recipes’ given by these ancient authors have been occasionally reproduced. According to this corpus of research, this industry had a number of requirements, such as raw material, artisanal craftsmanship, equipment and installations and space. Requirements relevant to our discussion of the character of ‘murex’ dye production at Troia are those that leave material signatures in the archaeological record.

The first requirement of ‘murex’ dye production is one that is common to all ancient and modern industries: obtaining sufficient amounts of raw material at a low cost, in this case the live mollusks. *H. trunculus*, which can survive both on sandy and rocky substrates in coastal zones, are easy to gather by hand. Individuals do not bury themselves in soft substrates, making the communities easy to locate by predators. But the low density of *H. trunculus* communities (low in relation to cockle or mussel beds for example) can turn the hand-collecting of this species into a time and energy consuming task. Instead, these carnivorous marine snails can be caught by baited baskets or ceramic pots.[25] Individuals, which gather up into vessels in order to scavenge the meaty bait, are thus captured without much difficulty. In other words, individuals can be fished. Larger quantities of preferably larger (hence older) individuals mean more dye.

The second requirement for the production of dye is obviously the technological know-how, especially for the production of larger quantities of dye. The above-mentioned knowledge of baiting the carnivorous Muricidae snails can help by improving the time and energy consumed to acquire the individuals of these species. In order to ‘fish’ the animals, the human predator must have observed the snails consuming flesh. This observation may have led to the ability to capture larger quantities of murex snails and consequently to the beginning of substantial local dye industries. The use of this method may have been introduced to the Aegean during the Middle Bronze Age, linked to the development of dye industries elsewhere in the Mediterranean. Earliest evidence for ‘murex’ dye production comes from the central Mediterranean region and dates back to the Early Bronze Age.[26] Textual, pictorial, and archaeomalacological evidence suggests that manufacture of this dye from *H. trunculus* remains was already known in Middle Bronze Age Aegean (ca. 2000–1750 B. C.) by the Minoans (see below).[27]

Another aspect of technological requirements is obtaining the dye from the animals. The first step of the basic method of dye production technology is to extract the hypobranchial gland from the shell, which will only precipitate color when exposed to air.[28] Although the hypobranchial gland can be removed by hand or by piercing the shell, the most efficient method to produce massive amounts of dye is to expose the gland to air by crushing the shell enveloping the soft body of the animal.[29] This is the reason why only crushed Muricid shells are shown as evidence for dye production.

The technique of producing dye from marine snails additionally involves various equipments and installations, such as vats and basins.[30] The exposed hypobranchial glands have to be oxidized by air for three days prior to a long cooking phase.[31] Remains of such installations associated with Muricidae remains have been found elsewhere in the Mediterranean.[32] A basin in Sarepta (Lebanon) still contained dye-residue at its bottom at the time of recovery.[33]

A final requirement, one which is also valid for most industries today, was perhaps to minimize the influence of the offensive smell produced by not only the chemical production process but also by the decaying organic remains of the shells on the residential areas of settlements.[34] While one may think that ‘murex’ dye production took place some distance away from the settlements in

order to fulfill this requirement, archaeological evidence from later sites in the Mediterranean seems to indicate otherwise.[35]

While producing 'murex' dye production has its necessary steps and requirements, the dye itself is not a necessity. Any type of dye-production might be a by-production, and the dye usually just one of the components of the end-product. Whatever the end-product may be, the dye does not constitute an essential ingredient but rather an enhancement to the product. Dyes are produced for the intrinsically artistic purpose of dying, the dye is a luxurious amendment to another product to make it richer. 'Murex' dye production in the Mediterranean has almost always been and quite correctly associated with local textile industries.[36] Large amounts of snails are required to manufacture even the smallest amount of dye necessary to affect the tiniest piece of textile.[37] Ruscillo reports that her experiments with the murex dye required 160 individuals to produce 590 ml dye, which were used to dye four swatches of 15 cm x 20 cm of cloths.[38] This result confirms the opinion that only large quantities of Muricidae remains can be shown as evidence for dye production and its relation to textile industry.

Recent studies tend to break this dogmatic view that only 'large' quantities should be shown as remnants of an 'industry'. Becker introduced the idea that small quantities of Muricidae remains can also be considered as remnants of dye production, albeit at a house-hold level.[39] The idea was adopted immediately; most recently by Veropoulidou *et al.* to discuss some Muricid remains from Thessaloniki Toumba.[40] Becker's suggestion[41] is one way of explaining small patches of crushed *H. trunculus* remains found in the archaeological contexts of the Mediterranean, including those isolated finds at Troia. But there are two other possibilities to explain small amounts of archaeological *H. trunculus* remains: (1) they may have been the shells of those individuals used for fishing bait; and, (2) although they may have been used in dye production, they were not used to color textile, but to produce temporary tattoos in a manner similar to henna. Ruscillo notes that the stain of the 'murex' dye remains on the hands for about a month after the production process.[42]

Contexts and character of "Murex" shells from the Early Excavations at Troia

As mentioned above, the first scientist to comment on the mollusk remains from Troia was E. von Martens.[43] He identified the archaeological and modern specimens presented to him by R. Virchow, H. Schliemann's naturalist, who accompanied Schliemann on his excursions to Troia. Von Martens commented on a number of molluscan species represented in the earlier excavations at Troia, including two species of Muricidae: *Murex trunculus* and *Purpura haemastoma*.[44]

In his report on the molluscan remains from Troia, von Martens dedicated a paragraph to the discussion of the nature of the dye industry at the settlement, reporting that great numbers of *H. trunculus* remains appear at the site mainly in angularly broken pieces and in accumulations which did not include remains of other molluscan species.[45] It is almost certain that von Martens gathered this piece of information from Virchow, since von Martens himself never joined Schliemann's excavations at Troia. He concluded his discussion about the mollusk remains by correctly suggesting that the majority of the mollusk remains found in the deposits of Troia represents food refuse.[46]

In 1881, Virchow quoted much of von Martens' work in his contribution to Schliemann's monograph *Ilion* on the excavations at Troia.[47] By this time, probably upon von Martens' initial comments on the *H. trunculus* remains from Troia and with the scholarly influence of Virchow, Schliemann himself started paying more attention to the biological remains at the site.[48] In the renewed excavations at Troia, Schliemann reported that he found a layer consisting exclusively of crushed *H. trunculus* shells below the highest stratum of "the Wall of Lysimachus", associated with a time when painted vessels were in fashion.[49] We now understand that Schliemann's "Wall of Lysimachus" is nothing else but the Troia VI citadel wall[50] and the fashion of painted vessels undoubtedly refers to the Mycenaean wares of the Late Bronze Age. Although he did not specify the exact position of this find, the location he mentions can be reconstructed in the area of his southeast trench, which cuts through House VI G and the Troia VI citadel wall (see below).

During the 1894 season of excavations, Schliemann's immediate successor W. Dörpfeld found heaps of crushed 'murex' shells inside the citadel of Troia VI.[51] The exact location of this concentration was, again, not specified, but since the 1894 excavations were conducted mainly on the eastern and southern parts of the Troia VI citadel, the shell concentration mentioned should be located within the borders of this area of the site.[52] Otherwise Dörpfeld concentrated his work on understanding the stratigraphy of Troia and its link with the Trojan War, largely disregarding remains other than artefactual nature in his reports.

From C. W. Blegen's excavations we know more about the stratigraphic contexts of 'murex' remains and their datings.[53] However, in a manner similar to the notes on the rest of the faunal remains, data on the mollusk remains from the Cincinnatti excavations were not provided in quantified form in the final excavation

monographs. Further information on the faunal remains from Blegen's excavations was provided by the Swedish archaeozoologist N. G. Gejvall,[54] who was mainly interested in the vertebrate remains from the site. In accordance with his research focus Gejvall's discussion on the molluscan remains was limited to a brief reference to the existence of a "purple industry" at Troia, based on "a great many purple shells" found in "a small area of Troy VI".[55]

In Blegen's excavations, 'murex' shells appear in all Bronze Age settlement periods, from Troia I to Troia VII. They are more frequent at Troia VI, especially in the later phases of this period. At Troia VI Early some murex shells were found in House 630 in the southern area of the citadel in squares FG7/8.[56] This building was dated to the early phases of Troia VIa and VIb. Further examples were uncovered in the area to the southeast and immediately outside the earlier citadel wall in square J7 in various deposits dating from Troia Early (phase VIb)[57] to Troia VI Middle (phases VId–e).[58] Since Blegen did not mention any traces of treatment on the murex shells from these contexts, we do not know whether they were found as crushed shells or complete specimens. Their relatively lower frequency compared to the remains of other mollusk species found along them implies a use for dietrary purposes rather than dye industry.

At Troia VI Late (phases VIf–h) the frequency of 'murex' shells increases drastically. In the eastern area of the citadel, in squares HJ7/8, successive deposits containing many 'murex' shells were found. Shortly after the eastern citadel wall was completed (phase VIf), the open area immediately behind that wall was slightly raised with fill deposits,[59] one of which contained a large amount of 'murex' shells. Unfortunately, Blegen did not mention whether they were crushed or not. At the end of phase VIf a deposit consisting mainly of debris from the remodelling of House VI F was thrown into the street between this building and the citadel wall.[60] This deposit also contained many angular 'murex' shell fragments.[61] In the following phase VIg and after the construction of House VI G, the level of the eastern street was raised once more. While the lower part of this fill deposit consisted of building debris, the upper part was made up of at least two distinguished layers of crushed murex shells.[62] This shell deposit was up to 30 cm thick on the southeastern side of the street, running up against a wall along the inner side of the citadel wall.[63] Towards the middle of the street the murex shell deposit became thinner. Blegen was able to trace this layer some 20–30 m towards the north. The layer is thus attested in the areas between the cidadel wall and Houses VI F[64] and VI E[65] as well.

In his preliminary report Blegen concluded that House VI G and/or its vicinity were used as a factory for the production of purple-dye.[66] To this evidence he added many stone grinders and pestles which were found in these deposits and postulated that they may have been used for crushing the shells. Curiously, in the final publication there is no word about purple-dye production anymore, possibly because no further installations were found inside and around House VI G. The crushed murex shell deposit which Blegen had exposed seems to have extended further south as well. With his south-eastern trench Schliemann had cut through the southern part of House VI G and the upper part of the citadel wall,[67] digging right through the street where the murex shell layer was especially thick as we know from Blegen's results. Schliemann's description of a deposit consisting only of crushed murex shells and their appearance just below his so-called "Wall of Lysimachos" fits perfectly with the situation in squares J7/8. To this we may also add Dörpfeld's excavations in square H8 on the opposite side of Schliemann's south-east trench.[68] The crushed murex shell deposit extended for at least 55 m covering an area of more than 400 m^2. Based on an average thickness of 5 cm it accounts for a minimum of 20 cubicmeters of crushed murex shells. The character of this shell deposit is clearly of secondary nature for the material was used as a fill for raising the street level. But the enormous amount together with the treatment of crushing the shells speaks clearly against their use for a dietary purpose but for the extraction of the animals' glands to receive the purple-dye.

In the final phase of Troia VI, phase VIh, the level of the eastern street was once more slightly raised with fill deposits containing murex shells.[69] Murex shells were also found inside some of the buildings from Troia VI Late. From the upper floor of House VI F and the fill above only murex shells were noted.[70] The upper floor probably belongs to Phase VIg; the fill above was mixed with some material of Troia VIIa.[71] Inside the Pillar House some murex shells were found in the floor deposits dating from phases VIf to VIh.[72] In the remains of a house in the eastern lower town in square K8 a large two-handled vessel was found standing on the floor. The interior of the vessel was thickly coated with lime. It contained a shell of *murex trunculus* and other animal and fish bones. Blegen wondered if these peculiar contents could be the reminiscent of a meal.[73] The thick accretion inside of the vessel rather points towards its use for the transport of lime, the shell and bones were probably stored here for another but unknown reason.

Murex shells are also attested in the following phase Troia VIIa. Again, in the eastern area of the citadel in squares JK6, Blegen found crushed shells in a deposit consisting mainly of building debris.[74] Its position right above the earthquake tumble and below the floor of House VIIζ points towards a date at the beginning of phase VIIa rather than VIh. Murex shells were found in varoius contexts of phase Troia VIIa such as street fills[75] and floor deposits within several houses.[76] Since there is nothing mentioned about their taphonomy, they can-

Period	Square	Behälter	Type of context	Species Composition
VI Early	KL16/17	632	Hearth	Ca. 95% crushed *H. trunculus* and *Patella spp*. and *C. glaucum*.
VI Early	KL16/17	690	Shell midden	Ca. 65% *Patella spp*., 30% crushed *H. trunculus* and a few *C. glaucum*.
VI Early	K8	635	Floors and floor deposits	70% crushed *H. trunculus* and 30% *C. glaucum*.
VI Early/Middle	İ8	50	Destruction/levelling deposit	60% crushed *H. trunculus*, 35% *C. glaucum* and a few *M. galloprovincialis*.
VI Middle	A8	1301	Fill in posthole of Grubenhaus	Ca. 72% *S. marginatus*, 12% *C. glaucum*, 15% *M. galloprovincialis* and a few *H. trunculus*.
VI Middle	KL16/17	225, 1070	Pit fill	95% crushed *H. trunculus*, a few *C. glaucum* and *S. marginatus*.
VI	K17	1534	Deposit	crushed *H. trunculus*
VI Middle or VI Late	İ8	448	Either from a) destruction/levelling deposit or b) foundation trench of Citadel Wall	45% crushed *H. trunculus*, 45% *C. glaucum* and a few *M. galloprovincialis* and *S. marginatus*.
VI Late	y8	-	Hearth	crushed *H. trunculus*
VI Late	A8	-	Oven	crushed *H. trunculus*
VI Late	İ8	299	Fill deposit outside Tower VIh*	70% crushed H. trunculus, a few *C. glaucum* and *M. galloprovincialis*.
VI Late	İK8	752	Fill deposit outside Tower VIh*	80% crushed *H. trunculus* and 20% *C. glaucum*.
VIIa	K4	1040	Deposit immediately outside of Northeast Bastion	Ca. 82% crushed *H. trunculus*, 13% *C. glaucum* and a few *O. edulis*, *M. galloprovincialis*, *S. marginatus*.
VIIa	KL4	1208	Fill deposit inside well(?) outside Northeast Bastion	crushed *H. trunculus*
VIIa	KL16/17	174	Fill deposit	90% crushed *H. trunculus* and a few *C. glaucum* and *S. marginatus*.
VIIa	KL16/17	236	Deposit under floor north of wall 11	Ca. 85% crushed *H. trunculus*, 10% *C. glaucum*, a few *O. edulis*, *M. galloprovincialis* and *S. gaederopus*.

(*) = maximum depth of Blegen's excavations around Tower VIh, possibly contaminated.

Table 1 Archaeological contexts of accumulated *H. trunculus* remains from the New Excavations at Troia.

not be safely accounted for purple-dye production and could be food remains as well. From the final Bronze Age Phase Troia VIIb no contexts with murex shells are known from Blegen's excavations.

Some of the molluscan remains from the Cincinnati excavations have been transported to Minnesota, while another portion were sent to Stockholm, Gejvall's academic hometown.[77] These are isolated samples from a number of contexts from all periods represented at Troia. D. S. Reese, who analyzed the shell material in Minnesota and Stockholm, reports on a few examples of 'murex' remains coming from all occupational periods of Troia.[78] His 'murex' should be *"H. trunculus"*, since there are a few *"Murex brandaris"* in his species list. He also men-

tions the 'murex' shells from House VI F located in the southeastern sector of the Troia VI citadel.[79] Reese's studies seem to confirm Gejvall's accounts,[80] which also attribute the "murex" remains coming from Blegen's Troia VI levels to *H. trunculus*.

Of all these observations on the 'murex' remains from the early excavations at Troia, two points deserve emphasis: one is the concentration of the 'murex' remains recovered by Schliemann and Blegen in a sector of the excavations remaining inside the core area of the Late Bronze Age settlement and adjacent to the southeastern section of the Troia VI citadel wall. The other is Blegen's suggestion about the location of the dye industry.

Contexts and character of "Murex" shells from the New Excavations at Troia (Table 1)

The archaeobiological remains were treated rather differently in the new excavations of M. O. Korfmann than they were in the previous excavations. The molluscan remains were retrieved by hand along with other animal remains. In most cases only a small, arbitrary sample of 'murex' shells were collected and the rest was discarded during excavation. The molluscan content of each meaningful archaeological unit (the so-called Behälter at Troia) was kept and studied separately. An exceptionally large archaeozoology team, students as well as advanced scholars led by H.-P. Uerpmann conducted the on-site analysis of the faunal remains from the new excavations at Troia between 1989 and 2004. The specimens were identified, counted, weighed and registered by the archaeozoologists on the site using a KNOCOD database.[81] About 161,920 faunal specimens recorded this way could be ascribed to meaningful chronological and stratigraphic units. Altogether they amount to 989,705 g, i. e., almost one metric ton. The molluscan remains account for 33.7% of the number (NIS) and 19.5% of the weight of the identified specimens (WIS). Because the remaining portions of the mollusk remains have not been observed and recorded systematically, minimum number of individuals (MNI) could not be estimated for statistical purposes. Admittedly, since Muricid shells were almost exclusively found in crushed form, MNI estimations based on present portions would be more useful than NIS counts for assessing their actual amount per each excavated cubicmeter.

The proportion of the molluscan remains in the faunal assemblages differs between chronological and stratigraphic units. The molluscan remains represent at least fifteen families of aquatic mollusks, but most of them consist of *Cerastoderma glaucum* (lagoon cockle) valves representing food refuse.[82] Also prevelant among the mollusk remains are the shells of Muricidae snails.

During the archaeozoological investigations specimens belonging to the Muricidae family were not distinguished into different species during the on-site recording of the faunal remains; all specimens of this family were recorded in the general database category of "Muricidae". About 80% of the shell remains were discarded after counting and weighing. The remaining 20% were re-examined between 2003 and 2005.

During this re-examination, in contrast with von Martens' identifications,[83] not a single *P. haemastoma* specimen was sighted in the archaeomalacological assemblages. Likewise, *Bolinus brandaris* was also absent in this portion of the molluscan remains. While it is possible that a small number of *B. brandaris* and *P. haemastoma* may have been registered along with specimens of *H. trunculus* during the archaeozoological recording of the faunal remains, their occurrence was probably very rare. Although von Martens includes *P. haemastoma* in his list of mollusk remains from Schliemann's excavations,[84] based on archaeomalacological assemblages from the new excavations and Reese's reports it can be argued with confidence that among the species of marine snails suitable for the production of this organic dye, *H. trunculus* predominates at Troia.

The remains of *H. trunculus* are present in all occupational layers of Troia. Their remains are negligible in deposits dating to the Early Bronze Age (Troia I–III). The species starts to appear in slightly higher amounts in the assemblages belonging to the layers ascribed to the Middle Bronze Age (Troia IV and V), but it is still only represented by isolated finds. *H. trunculus* makes its first noteworthy appearance in the Early Troia VI assemblage with 8.2% of the NIS and 7.4% of the WIS. The share of *H. trunculus* remains continues to be high in Middle and Late Troia VI, making 18.5% of the NIS and 20.3% of the WIS of the assemblages dating to these occupational layers. The proportion of *H. trunculus* remains reaches its peak in the assemblages of Troia VIIa. In fact, the species becomes the most frequent mollusk found in these layers, with 35.8% in NIS and 53.3% of the WIS. The share of *H. trunculus* decreases drastically down to 4.5% of the NIS and 5.6% of the WIS in the Troia VIIb phase. It must be mentioned here that the species composition of the mollusk assemblage dating to the Troia VIIb phase. otherwise does not represent a large contrast with Troia VI and VIIa. The *H. trunculus* remains constitute only slightly more than 1% of the molluscan assemblages of the Post-Bronze Age layers. In summary, the most significant amount of *H. trunculus* remains are found in the Late Bronze Age deposits of Troia, most notably in the latest phases of Troia VI and VIIa.

Almost all the observed *H. trunculus* specimens are exceedingly fragmented (Fig. 1). They are crushed. More

intact specimens belong to younger (smaller) individuals, but they too are missing at least the aperture lip.

The earliest evidence for 'murex' dye production comes from the southern lower town of Troia VI/VII in squares KL16/17 with findings of several concentrations of crushed *H. trunculus* shells. Here, a square-shaped hearth was found integrated into a flagstone pavement.[85] The hearth was constructed with 16–18 cm thick mud-brick tiles on the outside; the inner area was paved with stones. The outer dimensions of the hearth are about 1.25 m x 1.25 m. An additional row of stones arranged in an oval shape rested on top of the pavement, forming the actual fireplace. The lower part of the hearth was built of a layer consisting of 95% of crushed *H. trunculus* shells (Beh. KL16/17.632). More crushed *H. trunculus* shells were found underneath the stone pavement. Next to the hearth a deposit containing crushed murex shells was exposed. This consisted of ca. 30% of *H. trunculus* (Beh. KL16/17.690). Noteworthy is the significant presence of other mollusk species in these deposits. Beh. KL16/17.690 is in fact dominated by limpet shells (*Patella* spp.) and also contains some lagoon cockles (*C. glaucum*), whereas Beh. KL16/17.632 inside the hearth, while predominated by *H. trunculus* remains, contained also some limpets and cockles. A nearby levelling deposit in the same area (Beh. KL16/17.699) consisted of accumulated razor clams (*Solen marginatus*) together with a few cockles and limpets. Each of these species represents distinct coastal habitats and different types of shellfish gathering activity. Additionally associated

Fig. 1 Crushed *H. trunculus* remains from Troia.

with these finds were animal remains. All these findings are now dated to the earliest phase of Troia VI, i. e., Blegen’s phase VIa.[86] Korfmann had already concluded that the installations were used for the production of purple-dye.[87] The animals were probably boiled on the hearth, the shell remains were dumped nearby. The small amount of *H. trunculus* remains indicates that the purple-dye production in this area was small-scale. Accumulations composed of other mollusk species and animal remains indicate that the area of the hearth was not solely used for dye production but also food preparation.

Nevertheless, these installations and deposits in squares KL16/17 allow us to make two new observations about ‘murex’ dye production at Troia: first that, although on a small-scale, the manufacture of ‘murex’ dye already started at the settlement in the later Middle Bronze Age – much earlier than previously known; second that the dye was actually produced inside the settlement.

Evidence from the following phases of Troia VI comes from the eastern lower town in square K8. A series of subsequent floor and floor deposits (Beh. K8.635) containing crushed *H. trunculus* remains (70% of the mollusk content in NIS) and *C. glaucum* (lagoon cockles, remaining 30%) were discovered here. The floors are related to a house that was erected and remained in use during the second phase of Troia VI (= Blegen’s Troia VIb) in this area. A little further to the southwest in square İ8[88] a further deposit of crushed *H. trunculus* shells was found in levelling deposits consisting of building debris (Beh. İ8.50). The latter contained material mainly from the last occupation phase of Troia VI Early (= Blegen’s phase VIc), the levelling took place at the beginning of Troia VI Middle (= Blegen’s phase VId). This deposit was also not solely made up of *H. trunculus* remains; the ‘murex’ made ca. 60% of the deposit, the remaining portion was made of ca. 35% lagoon cockles and a few mussel shells (*Mytilus galloprovincialis*).

In the western lower town in square A8, a Grubenhaus dating to Troia VI Middle was partially excavated.[89] One of the postholes of this house was filled with a shell deposit predominated by razor clams. Along with razor clams were remains of lagoon cockles and mussels, as well as a few *H. trunculus* remains. While this deposit represents one of the extraordinary mollusk deposits of the Troia VI period on the mound, its direct relationship with the ‘murex’ dye production of the period is improbable.

The evidence for ‘murex’ dye production at Troia becomes more abundant at Troia VI Late. In the western lower town a hearth and an oven were found with crushed shells of *H. trunculus* as construction material. The hearth in square y7 had a diameter of 1.16 m and was built of two layers of flat stones, a layer of small pebbles, a layer of crushed shells and finally a layer of clay. In square A8, an oven with a diameter of 1.2 m was discovered on a street.[90] Its base was erected in a similar way as the hearth in square y7: a thin layer of clay, a layer of sherds, again a clay-layer ca. 3–4 cm thick, then a 1–2 cm thick layer of crushed shells and finally another 3–4 cm thick layer of clay.

Outside Tower VI h in squares İK8, the mollusk content of a street fill (Beh. İ8.299 and İK8.752) contained 70–80% of *H. trunculus* remains in crushed form. The remaining portion of the mollusk remains in these deposits included lagoon cockles and mussels. This deposit probably dates to the final phase of Troia VI, but the stratigraphic position of the find does not allow for a more secure dating.[91]

There is also new evidence from Troia VIIa. In squares KL4 in the eastern lower town and just outside the Northeast Bastion or Tower VI g, two deposits of crushed *H. trunculus* shells (Beh. K4.1040 and KL4.1208) were discovered recently. One of the deposits lies on the southeastern side of Tower VI g and consists primarily of crushed *H. trunculus* remains (ca. 80%), but also of the remains of various edible mollusks. Its thickness varies between 6 and 23 cm, with an average thickness of ca. 12 cm. Like all the other deposits here, this crushed shell layer is sloping down towards the east. The other shell deposit is a few meters further southeast. Here, a huge rectangular pit – probably a well – was cut into bedrock. Only its northeastern corner was exposed during the excavations, its minimum depth is about 1.8 m without having reached the bottom. The pit/well is filled with several layers of earth, sand and charcoal, all displaying a distinct and sharp slope upwards at the eastern side of the pit/well, indicating that they were filled in from this direction. One of these fill deposits (Beh. KL4.1208) consists only of crushed ‘murex’ shells. This deposit is up to 12 cm thick. Both of these shell layers in KL4 were deposited at the beginning of phase VIIa.

In the southern lower town in squares KL16/17 a fill deposit with mollusk content up to 90% of crushed *H. trunculus* (Beh. KL16/17.174) and a deposit underneath a floor containing 85% of crushed *H. trunculus* (Beh. KL16/17.236) are dated to Troia VIIa. These later ‘murex’ deposits are the witnesses of this area’s long tradition in the production of ‘murex’ dye.

From the new excavations there are no significant accumulations of crushed murex shells from contexts dating to the final Bronze Age phases of Troia VIIb. As mentioned above, archaeomalacological assemblages from Post-Bronze Age cultural layers of Troia contain less than 1% of *H. trunculus* remains and certainly no accumulations of the sort described from the Late Bronze Age periods of the site.

Results from old and recent excavations show that most of the *H. trunculus* remains dating to the Troia VI period originate from the southeastern sector of the Troia

VI citadel. The earlier excavators of Troia report that large accumulations of *H. trunculus* remains covered vast areas immediately behind the Troia VI citadel wall.[92] The deposits of *H. trunculus* found in squares İ/K8 immediately outside the fortification wall and Tower VI h may be connected to the deposits reported by Blegen in squares J7/8 between House VI G and the fortification wall and Schliemann's excavations in this vicinity. The *H. trunculus* accumulations in these areas are secondary deposits associated with dispose (*e. g.*, pits) and construction (*e. g.*, levelling of streets, oven/hearth). Their spatial distribution cannot be directly related to the actual location of dye-production, as it was suggested by Blegen.[93]

Besides the remains in squares İK8, other accumulations of *H. trunculus* shells have been found at Troia during the new excavations. These concentrate in squares KL4 and KL16/17. Moreover, all other archaeological units that contain a large number of *H. trunculus* remains include the shells of food species. Neither the deposits uncovered by Blegen's team nor the accumulations found in the new excavations consist solely of *H. trunculus* remains. This situation is in contrast with Virchow's reported claim that the *H. trunculus* deposits at Troia solely consist of the remains of this species and no others.[94]

Discussion

When we discussed the methods of 'murex' production methods (see above), we talked about different aspects of this process, some of which are absolute prerequisites for a sustainable manufacturing process, whereas others are associated elements of it. Let us now go back to these aspects and see how 'murex' dye production at Troia can best be reconstructed accordingly.

First and foremost we mentioned the requirement of raw material, namely the snails. Obtaining raw material was not a problem at Bronze Age Troia. The western coast of the Aegaean was famous for murex snails in antiquity; Aristotle especially mentions the rich shores from Sigeion (c. 6 km west of Troia) to Lekton (c. 54 km southwest of Troia).[95] The Late Bronze Age settlement overlooked a shallow estuary,[96] which provided an ideal habitat for *H. trunculus* colonies. The presence of *H. trunculus* remains at all periods of occupation at Troia attests that the inhabitants of the site exploited this habitat for variable amounts of *H. trunculus* catches from the beginnings of occupation at Troia until the Byzantine period.[97] *H. trunculus* could be collected or baited from rocky and sandy substrates in the mid and northern sections of the bay, at a considerable distance from the deltaic lagoons of the Scamander River, but in still shallow areas.

This location was some distance away from the settlement, requiring considerable time and energy for the transportation of large amounts of raw material to the site. The Late Bronze Age inhabitants of Troia may have solved this problem by placing the main production site outside the settlement and closer to the bay in the Scamander Plain, near the natural habitat of these snails. It is quite plausible that this was the case during Troia VI Late and VIIa. During these periods, although the amount of crushed *H. trunculus* remains at the site is higher than ever before, their stratigraphic contexts all indicate a secondary or even tertiary nature. Considering the absence of evidence for a secondary use of the shell refuse for lime production or major building use, the presence of large amounts of *H. trunculus* remains in the residential areas poses a perplexity. The stench the manufacturing process produces is notorious.[98] Moreover, from these phases no installations connected to the production of 'murex' dye have been found so far. Here, the question remains as to why the Trojans put so much effort in bringing the shell refuse up to the mound and into the settlement. Only when there was a sudden demand for huge amounts of filling material? This seems quite unlikely since earth and other kinds of debris were always at hand on the site itself. There may be two answers for this archaeological situation:

The shell deposits near the Northeast Bastion (Tower VI g) clearly show that they were filled in from opposite directions: the one inside the pit/well was thrown in from the east and the one immediately next to the tower from the west, i. e., from the higher ground in front of the citadel. The pure character of these deposits, along with the pits filled with crushed 'murex' shells in the southern lower town, may indicate that they were accumulated gradually as refuse material produced on the spot or very close by instead of being transported from further down in the plain only to be dumped inside the settlement and without being mixed with other habitation debris. In other Late Bronze Age sites in the Eastern Mediterranean pits filled with crushed 'murex' shells have been discovered inside settlements as well.[99]

On the other hand, their pure character can indicate quite the opposite; that they were brought deliberately from the production site located outside the settlement, in order to construct leveling fills with a purpose including that of lime cover layers. Mollusk shells are composed of calcium carbonate, practically the same composition as limestone but biogenic, and hence have characteristics similar to limestone, such as providing good water shed and good breathing. As construction material, they can also serve as a health measure against unwanted bacteria and pesticides. At Kinet Höyük on the Gulf of İskenderun, broad layers of crushed 'murex' shells were placed between Late Iron Age building phases on one side of the

settlement, whereas a large contemporary industrial kiln on the other side was found in association with crushed ‘murex’ shells turned into lime.[100] Although installations or equipment directly associated with ‘murex’ dye production are also absent from the settlement debris at Kinet, it is clear that the crushed ‘murex’ were reused as construction material chosen for their specific qualities. Crushed shells’ secondary use in lime production for building material comes from other sites as well.[101] The secondary use of crushed *H. trunculus* shells as construction material is confined to the Period of Troia VI Late. Their use as a composite layer in hearths and ovens to absorb the heat may have been an experimental but short episode. The use of crushed shells for lime production has not been verified at the site, but seems quite unlikely since limestone is also readily available at the site itself.

Secondly, there is quite an elaborate process involved in the production of this organic dye and the technological know-how for it is best acquired by the transfer of ideas. The earliest appearance of concentrated heaps of crushed *H. trunculus* remains in the Aegean dates to the Middle Bronze Age. Before the Middle Bronze Age, *H. trunculus* remains constitute only a minute proportion of the archaeomalacological assemblages from the Aegean.[102] At least some of these represent beach-picked examples that cannot even be attributed to the past human usage of the animals’ soft body in any way,[103] whereas others, based on their fairly intact remains, are more likely to represent food refuse.[104] The earliest known accumulations of crushed *H. trunculus* in the Aegean Basin come from Middle Bronze Age Crete. Substantial amounts of crushed murex shells were found at Palaikastro, on the isle of Kouphonisi, and at Kommos dating to the Middle Minoan I–II period (ca. 2000–1750 B. C.).[105] The size and amount of these shell deposits are difficult to assess from published descriptions. While Stieglitz[106] talks about a “large surface deposit of murex shells” at Palaikastro, Reese[107] lists *c.* 53 *H. trunculus* fragments out of 317 mollusk specimens. The situation at Kouphonisi is similarly ambiguous: There, it does not seem to be quite certain whether the ‘murex’ finds belong exclusively to the Minoan layers or whether they are associated with what are thought to be Hellenistic installations for dye production.[108]

Slightly later are finds from the southern Aegean islands of Kythera (Middle Minoan III), Thera (Late Minoan IA) as well as from Aigina Kolonna and Asine (both Middle Helladic III), and Eleusis (Middle Helladic III, Late Helladic I and II) on Mainland Greece.[109] The relative abundance of “murex” finds is much more significant during this period; their numbers increase and become more common throughout the whole Aegean. Just as the one observed at Troia, there is a general increase in the proportion of *H. trunculus* remains in the archaeomalacological assemblages during this period.[110] Yet, at none of these sites the evidence seems to be as ubiquitous and abundant as at Late Bronze Age Troia. Nevertheless, Troia should be included in this early phase of expansion of purple-dye production in the Aegean. The first unambiguous evidence of ‘murex’ dye production at Troia comes from the first phase of Troia VI, phase VIa. This phase is equated with Middle Helladic III – in absolute terms, the beginning of Troia VI dates to ca. 1750 B. C.[111]

The taphonomic state of the *H. trunculus* remains from Troia is clear evidence for the chain of production applied in the dye production. As described above, the majority of *H. trunculus* remains at Troia, except for small individuals, consist of crushed shells. The fragmented condition of the *H. trunculus* remains at Troia show deliberate breakage. Due to the compact and solid nature of the *H. trunculus* shell, this type of fragmentation, *en masse*, could not have taken place after the deposition of the shells as a consequence of trampling, re-depositional activity or soil contraction. Shattering of the mollusk to extract the animal for human consumption is not a plausible explanation for the origin of this kind of breakage pattern. Almost all *H. trunculus* remains postdating the Middle Bronze Age in the Mediterranean were found in crushed form at varying degrees.[112] Earlier finds of dye producing snails in archaeological sites around the Aegean have been found largely intact, at best in small accumulations, or already beach-worn, indicating that they were used as food or that they were collected dead.[113] The amount of crushed *H. trunculus* remains as well as the fact they are located within the settlement proper makes the possibility very unlikely that these are remnants of raw material used in fishing bait. The crushed state of the shells altogether eliminates the possibility that these snails were used as human food prior to deposition. Crushed mollusks are not palatable because small sharp shell fragments can remain in the flesh, making the flesh difficult, if not impossible, to digest. As a result, both the amount and the taphonomic state of the *H. trunculus* remains at Troia demonstrate their use in the dye industry.

In addition to the vast evidence of the shells themselves, installations that might be necessary for the production of ‘murex’ dye are present at Troia. These, however, are not in close chronological or contextual association with the larger accumulations inside and near the citadel dating to Troia VI Late. Instead, we find evidence for the actual production process in the lower town. The installations in the southern lower town in squares KL16/17 consisting of a carefully constructed hearth surrounded by a pavement and in connection with several deposits and pits containing crushed murex shells as refuse material are important findings. The work that was done here included crushing the shells in order to extract the animals’ glands and probably also boiling these on

the hearth to prepare the colour dye. These procedures fit very well with the production technique of purple-dye as described much later by Aristotle and Pliny.[114] At the time of Troia VI Early, this area was lying at the fringes of the lower town.[115] Other installations and findings indicate metal-working here as well.[116] Both industries are well situated on the border of the settlement; the one with its notorious smell, the other with its constant handling of fire. Deposits of *H. trunculus* shells in square KL16/17 are in proximity with two other unusual shell deposits, which separately contain *S. marginatus* and *Patella* spp. shells. These species are not associated with any known ancient industry. They are edible and are still considered palatable in today's Mediterranean cuisine. At the same time, the amount of *H. trunculus* remains recovered in square KL16/17 does not suffice to indicate dye manufacture for a major textile industry. These points demonstrate that the purple dye production that took place at this area during the Troia VI Early times was not of large scale, but an activity closely associated with subsistence activities on a household basis. Korfmann's association of the "10 kg of *H. trunculus* remains" discovered in square KL16/17 during the 1997 excavation season at Troia with "a well-developed, sophisticated textile industry" has little ground.[117]

Evidence comparable to the one in squares KL16/17, though later in date, comes from other sites. In Aigina Kolonna an oven and related floors containing crushed shells of *H. trunculus* were exposed.[118] According to the excavator, the oven was used for firing ceramics. The related murex shell deposits indicate that purple-dye was produced here as well. The structure dates to LH IIIA1 which corresponds with Troia phase VIf (ca. 1400–1375 B. C.).[119] In Minet el-Beida a vessel stained with purple-dye was found in connection with crushed murex shells and a near-by hearth. It was dated generally to the 15th–13th century B. C.[120]

So far, the features in the southern lower town are the only clear evidence for the actual on-site production of purple-dye. Large-scale installations associated with *H. trunculus* accumulations were not traced at Troia. A possible location for these installations is the lower Scamander plain, near the shellfishing grounds exploited for the procurement of the raw material. Such an arrangement not only reduces the transportation costs, but also keeps the stench produced during production away from the settlement proper. However, it is also possible that at Troia, instead of vats and shallow basins, pithoi or other vessels were used to oxidize the glands by way of occasionally stirring the decaying mixture once in a while. This is, however, a relatively labor-intensive process.

It was already mentioned that purple dye production is not a necessity, but a luxury, most often associated with a textile industry. Considering this, it seems no coincidence that the increase in the production of both purple-dye and textiles occured simultaneously at Troia VI Late. Textile production has always been practiced intensively on the site during the whole Bronze Age, from Troia I to Troia VII.[121] The refinement of textiles with purple-dye added a much higher value to these products. The demand for these highly priced garments is documented in the written sources of the Late Bronze Age eastern Mediterranean.[122] New evidence comes from the near-by island of Lesbos referring to purple-dyers that belonged to the "Hittite Great King."[123]

Troia was part of a maritime Aegean trade and exchange network already in the Early Bronze Age and maintained and developed cultural contacts with other settlements in the region in the eras that followed. Other archaeological evidence supports the idea that the Trojans learned about the technique of producing dye from marine snails from their southern neighbors. Troia participated in the exchange network of the eastern Mediterranean as indicated by the foreign objects imported from Cyprus, the Levant and even Egypt – all of them found in contexts dating to Troia VI Late and VIIa.[124] The wealth of the settlement of Troia VI Late is clearly reflected in the grand architecture of the citadel and the buildings within. We postulate here, that textile production in general and especially the refinement of some of these textiles with purple-dye played a major role in the economy of Late Bronze Age Troia.

Conclusions

The present study evaluated *H. trunculus* remains from Troia by incorporating the results from older excavations at the site and by comparing the combined evidence with other cases in the eastern Mediterranean. Only small amounts of *H. trunculus* remains were found in deposits pre- and antedating the settlements of Troia VI and VIIa. This situation suggests that the specimens from the Early and Middle Bronze Age settlements of Troia I–V, and the Post-Bronze Age settlements of Troia VIII and IX were consumed as food or used as fishing bait, and possibly to tattoo the body. Crushed *H. trunculus* remains in sufficient amounts come only from the Late Bronze Age layers of Troia, starting from the very beginning of Troia VI (phase VIa). The current evidence indicates a self-sustained, medium-sized industry, but only from a diachronical point of view. In view of the cultural and chronological context of the Late Bronze Age Aegean, what can be concluded from the present evidence is that the 'murex' dye production of the settlements of Troia VIa through Troia VIIa was a flourishing one, probably

representing an industry enhancing the growing textile production at the site.

While it should be acknowledged that although the Late Bronze Age *H. trunculus* remains at Troia are fairly abundant and there is good reason to consider that they represent only the tip of the iceberg, the extant evidence is not comparable with the very large shell heaps from the Iron Age sites on the Levantine coast like Tyre and Sidon.[125] There, the remains consisted of a 120 m long and 7–8 m high midden of broken Muricidae snails only, representing archaeological evidence adequate for the mass production of the famous ancient purple dye.[126] These heaps are located outside the residential areas of the settlements, indicating the special character of the industry. An even marked allocation of work space for this industry is visible in the site of Khor-Isle Sud on the island of Qatar in the Persian Gulf. Far away from any settlement this small workers’ site was exclusively used for the production of purple-dye during the Late Kassite period (13th–12th centuries B. C.).[127] Such instantly recognizable evidence is clearly not represented by the archaeological remains of *H. trunculus* at Troia. Nevertheless, evidence for ‘murex’ dye production at Troia represents the most abundant evidence for this industry from the whole Late Bronze Age Aegean. For more accurate evaluations of the archaeomalacological evidence for ‘murex’ dye production in the Mediterranean basin, intersite compatibility of accurate recovery and quantification techniques would be necessary in future studies.

The similarity between the relative abundance of species in the assemblages dating to the Troia VI and VIIa settlements affirms the suggestions that environmentally, culturally and economically Troia VIIa was a continuation of the Troia VI period. The presence of crushed *H. trunculus* remains in the deposits of Troia VIIa demonstrates that the custom of dye manufacture continued from the Troia VI period. The relative abundance of food species is not markedly different in the subsequent Troia VIIb period, but the decrease in the abundance of *H. trunculus* remains in the excavated areas points to a sharp decline of the dye manufacture.

The bulk of the *H. trunculus* remains from Late Bronze Age Troia represents an archaeological case that demonstrates the effects of technological and cultural innovations on the archaeomalacological record. The increased abundance of *H. trunculus* remains in the Late Bronze Age layers at Troia is part of a collective trend we see at contemporary sites elsewhere in the Aegean. It is hardly surprising that the earliest evidence of purple-dye production at Troia occurs just at a time when there is a distinct influence from the southern Aegean visible in the archaeological record of the site.[128] The Minoan interest in the northeastern Aegean is also clearly shown in the findings from the settlements on the near-by islands of Samothrace and Lemnos.[129] The Minoan impact on Troia seems much stronger than the rather few Minoan artefacts may suggest, since it included the transfer of knowledge in the production of purple-dye and also new techniques in textile manufacture.[130]

Notes

[1] Reese 1980; Sabelli 1979. The Hypobranchial gland is sometimes also called mucus tract.
[2] Baker 1974.
[3] Reese 1980.
[4] Becker 2001.
[5] *Odyssey* 6.53.306.
[6] *Natural History* 9.62.135.
[7] For a review of textual evidence see: *e. g.*, Blum 1998; Reese 1980; Ruscillo 2005.
[8] Ziderman 1987.
[9] Von Martens 1879. See also Virchow 1881.
[10] *E. g.*, Ackermann 1996; Baker 1974; Ruscillo 2005; personal com. A. Aksoy of Çanakkale 18 Mart University.
[11] *E. g.*, Becker 1996, 2001; Çakırlar 2003; Gates 1999; Karali 1999; Minniti 2005; Reese 1980, 1987, 2000, 2005; Stieglitz 1994; Zidermann 1990.
[12] Becker 2001; Veropoulidou 2008.
[13] The former scientific name used for *H. trunculus* is *Murex trunculus.* Sabelli *et al.* 1990.
[14] Some scholars, *e. g.*, Demir 2003, consider Thaiidae as a subfamily of Muricidae, but here we follow the more common classification of Mediterranean gastropods. *Rapana* snails, another Thaid species occurring in the Marmara and the Black Sea, have been introduced in the 20th century from Japan.
[15] For the most recent report on such a deposit see Forstenpointer *et al.* 2007a.
[16] Demir 2003.
[17] Gaillard 1987.
[18] Rilov *et al.* 2004.
[19] Rilov *et al.* 2002.
[20] Ruscillo 2005.
[21] Gaillard 1987.
[22] ibid.
[23] Baker 1974.
[24] Davidson 1972, 192–193.
[25] Ruscillo 2005.
[26] Reese 2005.
[27] Reese 1987; Stieglitz 1994.
[28] Doumet 1980.
[29] Reese 1980.
[30] Becker 2001; Forstenpointer *et al.* 2007a.
[31] Stieglitz 1994.
[32] Gates 1999; Reese 1980; Stieglitz 1994.
[33] Reese – Rose 2002.
[34] Ruscillo 2005.
[35] Forstenpointer *et al.* 2007a; Bartosiewicz 2003.
[36] *E. g.*, Becker 1996 and 2001; Korfmann 1998, 52.
[37] Baker 1974; Doumet 1980; Reese 1980 and 1982; Ruscillo 2005; Stieglitz 1994.
[38] Ruscillo 2005.
[39] Becker 1996.
[40] Veropoulidou *et al.* 2008.

[41] ibid.
[42] Ruscillo 2005.
[43] Von Martens 1879.
[44] ibid., also later quoted in Virchow 1881, 134.
[45] von Martens 1879.
[46] ibid.
[47] Virchow 1881, 133–135.
[48] Schliemann 1881, 359.
[49] ibid.
[50] Dörpfeld 1902, 9.
[51] Schmidt 1902, 293, No. 7985.
[52] Dörpfeld 1902, 20ff, Pl. III.
[53] Blegen *et al.* 1950, 1951, 1953, 1958.
[54] Gejvall 1938 and 1939.
[55] Gejvall 1938, 52–55.
[56] Blegen *et al.* 1953, 123.
[57] Blegen *et al.* 1953, 146 (Stratum 8).
[58] Blegen *et al.* 1953, 196f. (Strata 6 and 5).
[59] Blegen *et al.* 1953, 267 (Stratum 4).
[60] Blegen *et al.* 1953, 315, fig. 482 (Strata 19 and 28).
[61] Rapp – Gifford 1982, 181f., Sample No. 342.
[62] Blegen *et al.* 1953, 269, fig. 476 (Stratum 3); Rapp – Gifford 1982, 160, Sample No. 179.
[63] Blegen 1937, 582, fig. 20.
[64] Blegen *et al.* 1953, 318, fig. 482 (Stratum 27).
[65] Blegen *et al.* 1953, 328, fig. 490 (Strata 3 and 4).
[66] Blegen 1937, 582.
[67] Schliemann 1881, Pl. I.
[68] Dörpfeld 1902, Pl. III.
[69] Blegen *et al.* 1953, 282f., fig. 476 (Stratum 2a).
[70] Blegen *et al.* 1953, 307, fig. 482 (Stratum 31 and Deposit B).
[71] Mountjoy 1997, 285.
[72] Blegen *et al.* 1953, 230.
[73] Blegen *et al.* 1953, 351.
[74] Blegen *et al.* 1953, 329, fig. 491 (Stratum 7).
[75] Blegen *et al.* 1958, 51 (Street 710), 123 (Area outside Eastern Gate VI S).
[76] Blegen *et al.* 1958, 66 (House 700), 70 (House 703), 73 (House 701), 117 (House VIIγ).
[77] Personal communication with D. S. Reese.
[78] Personal communication with D. S. Reese.
[79] Reese 1987.
[80] Gejvall 1938, 4.
[81] For details on the KNOCOD system see Uerpmann 1978. For further information on the methods used in the identification and recording of the molluscan remains see Çakırlar 2007.
[82] For a detailed evaluation of the molluscan remains from the new excavations see Çakırlar 2007.
[83] Von Martens 1879.
[84] ibid.
[85] Korfmann 1997, 59, fig. 63.
[86] In the preliminary report these structures were dated to Troia VI Middle (Korfmann 1997, 59; Korfmann 1998, 52). This has changed now due to a review of the stratigraphy and a detailed study of the ceramic material. We would like to thank P. Jablonka and P. Pavúk for this information.
[87] Korfmann 1998, 52.
[88] In the new excavations the grid column „J“ is designated with the turkish letter İ.
[89] Korfmann 2001, 20ff., fig. 18.
[90] Korfmann 1997, 40, fig. 27.
[91] This deposit was located at a depth where Blegen stopped his excavations. Since he did not mention any concentrations of ‘murex’ remains at higher elevations in this area and considering the close proximity of this deposit to the larger and more intact ‘murex’ shell deposit just on the other side of the citadel wall in squares J7/8, it is probable that the deposit found in squares İK8 are not pure.
[92] Schliemann 1881, 357; Blegen 1937, 582.
[93] Blegen 1937, 582.
[94] Virchow 1879.
[95] *Historia Animalium* 5.15.547.
[96] Kayan *et al.* 2003.
[97] Çakırlar, this volume.
[98] Ruscillo 2005; Stieglitz 1994; and personal communication with A. Aksoy.
[99] *E. g.*, Minet el-Beida (Schaeffer 1951) and Sarepta (Pritchard 1978, 126-7, fig. 121-2; Reese 1987, 206).
[100] Gates 1999; Çakırlar 2003.
[101] Çakırlar 2003; Gates 1999; Karali 1999, 45; Reese 1980.
[102] Çakırlar 2007; Karali 1999.
[103] Reese 1995.
[104] Boessneck 1986.
[105] Reese 1987, 204; Burke 1999, 79 (both with further references).
[106] Stieglitz 1994.
[107] Reese 1987.
[108] Stieglitz 1994.
[109] Reese 1987, 205 (with further references); Cosmopoulous *et al.* 2003.
[110] *Cf.* for example, Cosmopoulos *et al.* 2003; Gejvall 1969.
[111] Pavúk 2007, 476.
[112] *E. g.*, Becker 2001, Karali 1999, Reese 1987, and Forbes 1987.
[113] Karali 2005 and personal observation at the Neolithic habitation site of Yeşilova in Bornova, İzmir.
[114] Aristotle, *Historia Animalium* 5.15.22–25; Pliny, *Natural History* 9.125-142.
[115] Jablonka 2006, 175.
[116] Jablonka 2006, 174f.
[117] Korfmann 1998, 52.
[118] Gauss 2007, 165f., fig. 2; Forstenpointner *et al.* 2007b, 145f., figs. 4a, b.
[119] Mountjoy 1997, 287ff.; Mountjoy 1999, Tab. 1.
[120] Schaeffer 1951.
[121] Anderson – Guzowska – Becks (forthcoming).
[122] Singer 2008, 22–24, 29–31 (with further references); van Soldt 1990.
[123] Singer 2008.
[124] For Cypriote ceramics at Troia see Kozal 2006; for Levantine ceramics (Canaanite Jars) at Troia see Becks 2006, 161; Zurbach 2003, 121f., Cat. No. 30, fig. 26. A few ceramic sherds from Egypt were identified by M. Guzowska (personal communication).
[125] For further references on Tyre and Sidon see Reese 1987, 206, n. 49 and 50 respectively.
[126] Forbes 1987, 119.
[127] Edens 1999.
[128] For a summary of Minoan finds at Troia see Guzowska 2002; for finds from the southern Aegean including mainland Greece see Pavúk 2005.
[129] Matsas 1991; Matsas 1995; Pavúk 2005, 270f.
[130] For textile production at Bronze Age Troia see Guzowska – Becks 2005.

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