The Aplysia Sea Hare as a Dye Source Outsider for the Ancient Biblical *tekhelet*

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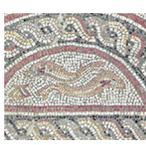
Abstract *– This study presents a series of arguments in favour of the Aplysia sea hare as a viable alternative to the commonly identified Murex mollusk for the historical identity of the marine dye source of the Biblical tekhelet. Aplysia, as a marine creature, matches key characteristics attributed to the tekhelet source in traditional Jewish texts. In addition, recent evidence suggests that Aplysia ink can serve as an effective dye, with optimal results in acidic conditions, consistent with the vat environment suggested by some overlooked Talmudic references. A sea creature in the Roman Lod mosaic may indicate the hunting of the tekhelet dye source. These arguments are still partial and call for the inclusion of the spectral signatures of Aplysia dyes in the analysis of relevant archaeological artefacts.*



Inhalt *– In dieser Studie werden Argumente zugunsten der Aplysia (Seehase) als brauchbare Alternative zu der Molluske Murex als historische Quelle des marinen biblischen Farbstoffs tekhelet dargelegt. Aplysia stimmt mit den Hauptmerkmalen überein, die der Quelle der tekhelet in traditionellen jüdischen Texten zugeschrieben werden. Darüber hinaus deuten neuere Belege darauf hin, dass Aplysia-Tinte als Farbstoff dienen kann, mit optimalen Ergebnissen unter sauren Bedingungen, die mit der Umgebung des Bottichs übereinstimmen, wie sie von einigen übersehenen talmudischen Referenzen vorgeschlagen wird. Eine Meerestier-Darstellung im römischen Mosaik im Triclinium von Lod könnte auf die Jagd der Quelle des Farbstoffs tekhelet hinweisen. Diese Argumente sind noch unvollständig und erfordern die Einbeziehung der spektralen Signaturen von Aplysia-Farbstoffen in die Analyse relevanter archäologischer Artefakte.*

Introduction

In antiquity, the *tekhelet* dye was a very expensive commodity in the Levant, essential for Jewish rituals. It was particularly used to dye some of the threads in the *tzitzit* tassels traditionally worn on the corners of garments, fulfilling the biblical command: "and they shall place upon the *tzitzit* of (each) corner a *tekhelet* thread" (Numbers 15:38). This dye was to come from a specific mollusk, designated in the Talmud as *khilazon* (*beraita* in TB *Menakhot* 44a). The exact identity of this mollusk was lost after the practice was interrupted sometime before the end of the first millennium CE.

Today, there is widespread support[1] for the theory that the Murex snail was the source of *tekhelet*, following some modern experimental results.[2] Proponents of this theory suggest[3] that both the ancient precious purple *argaman* and *tekhelet* share the same sea-snail family, Muricidae, as a common dye source, with the distinction between the two being a difference in hue: *argaman* being the famous purple widely discussed in antiquity,[4] while *tekhelet* is distinguished by its bluish hue. However, this identification remains a matter of halakhic controversy,[5] and on strictly scientific grounds it remains conjectural, as it is only supported by very few archaeological artefacts.[6]

A priori, in addition to the Muricidae, two major mollusk families, Epitoniidae and Aplysiidae, can be considered as potential sources for the biblical *tekhelet* dye. The former refers to the Janthina species, highlighted in our context by the doctoral thesis of Isaac Herzog,[7] later Chief Rabbi of Israel, whose research on the identity of the *tekhelet* source demonstrated a high level of familiarity with the best contemporary knowledge.[8] The second relevant group, less frequently cited in the *tekhelet* con-

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1 Sterman 2012.

2 e.g. Elsner – Spanier 1985.

3 A recent review of the pro and contra arguments for that theory can be found in Malkiel 2020, 7–21.

4 e.g., Pliny the Elder, nat. hist. 9, 61.

5 Sagiv 2015, 299–305. Among the points of uncertainty is the very hue that the tekhelet tassel actually had, which varies significantly depending on traditions and views, ranging from greenish light blue to dark blue nearly black, and through violet.

6 Sukenik et al. 2015, 569.

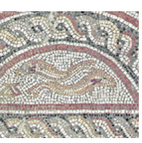
7 Herzog 1913; Herzog – Ron 1986, 71–75.

8 Travis 1989, 668. A recent prominent advocate for the Janthina source theory is

text,[9] is the Aplysia species, or sea hare, on which I focus here.

Aplysia as a source for the *tekhelet* dye

For a long time, contemporary research dismissed the possibility that Aplysia ink could be a source of *tekhelet*, based on the assumption that it lacked the essential properties for making a textile dye.



However, in a completely different research context focused on modern applications, two Korean groups have recently independently demonstrated that Aplysia ink is a valuable source for commercial textile[10] and hair dyeing.[11] Here I propose the Aplysia mollusk as a serious alternative candidate for the source of the biblical *tekhelet* dye.

Fig. 1: The Aplysia as responding to the 'fishy' ancient description (Alamy video 2KH7ED7)

First, the basic descriptive *beraita* (TB *Menakhot* 44a), which is difficult to interpret in the context of conventional sea snails, would have a straightforward meaning for our mollusk. The *khilazon,* it is said, "has a body that resembles the sea" (**1**), which fits the ever-wavy, wiggling motion of the Aplysia as it swims. It is also said that "its constitution resembles that of a fish" (**2**), an impression one can indeed get from the Aplysia mollusk,[12] especially given its lack of an external shell and its 'fins' and 'fishtail' (**Fig. 1**).

Fig. 2: An Aplysia stranding event (photo Augusta-Margaret River Shire; Wells et al. 2021, fig. 2)

As for the third feature noted in this *beraita* – the very rare coastal occurrence of the *khilazon*, a fact responsible for its high cost[13] (**3**) – it should be noted that the frequency of several species Aplysia along the eastern Mediterranean coast is characterized as "rare",[14] in contrast to Murex.[15] In addition, mass strandings of Aplysia (**Fig. 2**) have been reported in several parts of the world.[16] Such phenomena, which have not received a clear explanation, have been described as "an unusual but natural phenomenon".[17]

Another early traditional text that would benefit from clarification is the two-term expression "*khilazon*-serpent" (**4**), which appears in the Mishnah (*Bekhorot* 6:2) and is described as being almost synonymous in the Talmud (TB *Bekhorot* 38b). If the *khilazon* is an Aplysia,[18] with its streamlined, elongated profile, the suggested analogy to a serpent would not be particularly problematic.

It is noteworthy that traditional methods of using Aplysia mollusks to dye textiles are still practiced on certain Indonesian islands (**Fig. 3**). This process involves surface smearing, where the ink gland extracted from the mollusk is mas-

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the marine biologist Shaul Kaplan (Malkiel 2020, 22).

[9] Tavger 1993, 322 addresses the Aplysia option in a short footnote quoting it unsuitable as a dyeing source. Amar 2014, 168 devotes one sentence to that option and its difficulties.

[10] Kim – Kim – Jang 2012.

[11] Moon – Na 2018; Kim – Na 2024.

[12] While proponents of the Murex snail theory interpret the 'fish' attribute broadly as referring to a 'sea creature', this Talmudic indication provides more substance in our line of understanding.

[13] This seems the literal meaning here (Herzog 1986, 69).

[14] Barash – Danin 1992, 198–200. Gev – Achituv – Susswein 1984 indicated the presence of an additional species, Aplysia depilans, along the coast of Israel. However, given its reported high seasonal abundance on rocky, exposed shores, it can hardly enter our class of rare local Aplysia species.

[15] Proponents of the Murex theory either point to possible ecological fluctuations making the Murex rare at certain times or stretch the intended feature in the beraita to other interpretations and link the expensiveness to the small quantity of dye produced by each khilazon.

[16] Wells et al. 2021, with further references.

[17] Rudman 2001.

[18] Interestingly, the 11th-century Rabeinu Gershom commentary provides the Old French equivalent for khilazon in this passage (concerned only with general appearance) as limace, the terrestrial slug, which is indeed a close analogy to the marine sea hare.

[19] McIntosh – Peni 2021, 234.

saged into the yarns.[19] However, this method differs from the *tekhelet* thread dyeing process, which uses a vat.

Consideration of historical *tekhelet* dyeing conditions supporting the Aplysia alternative

A closer modern precedent can be found in the work of the cited Korean group,[20] who used a vat process (at an optimum temperature of 55°C), after extracting the gland from the sea hare.

One of their main results sheds some interesting light on a rather overlooked aspect of the traditional process of *tekhelet* dyeing. In textual sources such as TB *Menakhot* 42b, an integral part of the preparatory process involves the addition of an ingredient called *samanin*/*samemanim*, which is thrown into the heated vat along with the *khilazon*-extracted substance (5). These *samanin* are generally understood to be a standard mordant agent used to fix the dye to the wool. In the context of Murex purple dyeing, they are interpreted as a salt of a highly alkaline nature.[21]

However, a different picture emerges in another halakhic context in which these *samanin* also appear. There, intriguingly, they seem to have much in common with cereals used in bread-making.[22] Indeed, another Talmudic passage (TB *Menakhot* 43a) gives a recipe (as a test)[23] for increasing the hue by baking *tekhelet*-dyed linen in a strong barley leaven (6). In this recipe the conditions created are far from alkaline, being clearly highly acidic.[24] This could also have been the case for the *tekhelet* vat if the *samanin* were a type of cereal or pseudo-cereal, as some are known to produce lactic acid and a low pH environment through fermentation.[25] This seems to contradict the alkaline environment stated as crucial to the success of the purple vat.

However, this all fits into the context of Aplysia ink. The point is

Fig. 3: An Indonesian tradition of Aplysia thread dyeing by surface smearing (McIntosh – Peni 2021, fig. 44)

that acidification is the very condition observed by the Korean group[26] for optimal dyeing of their silk textile with Aplysia mollusk ink, increasing the color uptake by the textile and enhancing its blue component. Earlier experiments on the color properties of Aplysia ink had already shown that the blue component of the purple ink solution could be enhanced by an acidification process.[27]

While these results are only partial in the context of *tekhelet* dyeing research along these lines, they provide strong analytical support for considering Aplysia as a valid alternative historical source for traditional *tekhelet* dyeing.

Archaeological support for the Aplysia dye source?

If some local Aplysia species were indeed the source of the *tekhelet* dye, archaeological evidence would be difficult to find, unlike the massive piles of used shells found for the *argaman* Murex industry. Aplysia has an internal shell, but it is small and fragile[28]. Here, I will discuss possible iconographic support.

The Roman Mosaic in Lod has attracted considerable scholarly interest since its discovery in 1996, particularly for its maritime scene with remarkably rendered details. It has been suggested that these refer to the economic activity of the wealthy patron. Gorzalczany, Rosen and Sukenik have suggested[29] that the marine composition may have a reference to industrial

[20] Kim – Kim – Jang 2012.

[21] Koren 2013, 62.

[22] In the enumeration and review of the 39 principal works forbidden on the Sabbath (TB Sabbath 73a–75b), there is a group of such works related to the whole chain of bread preparation, from the initial sawing of cereal seeds through the harvesting, sorting, grinding, kneading and baking stages. Now, the text states (74b) that there is another parallel tradition in which the same chain of operations – besides the last one, baking, which is replaced by cooking – is enumerated not in relation to the preparation of bread, but to the preparation of samemanim (7), those needed for the dyeing of textile fabrics of the Tabernacle. Thus, these samemanim from this text reveal themselves to be some kind of cereals or pseudo-cereals suitable for operations similar to those used for cereals, including grinding and kneading.

[23] In the same Talmudic passage, another test is given of less clear ingredients, but it is only to test the fastness, and even if it fails, the test brought here is judged conclusive.

[24] The typical pH of a barley sourdough is around 3.5 (Marklinder – Johansson 1995, 366).

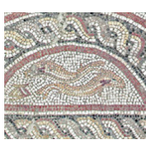
[25] An example is the common millet (Panicum miliaceum), which is known to have been cultivated in the Levant already in the first millennium BCE (Zohary et al. 2012, 71), and its Hebrew name, the dokhan (ibid., 69) is cited in the Mishnah (e.g. Shevi'it 2,7). This grain crop of short lifetime, when submitted to fermentation, produces lactic acid in a spontaneous way, i.e. without an additional external agent. For an example of such a spontaneous process still practiced in Africa, see Atter et al. 2024). Thus, the classical millet constitutes a valid historical possibility for the samemanim consistent with the alternative interpretation proposed here that the tekhelet vat was intended to reduce the pH, so as to create favorable acidic conditions for the mollusk dyeing.

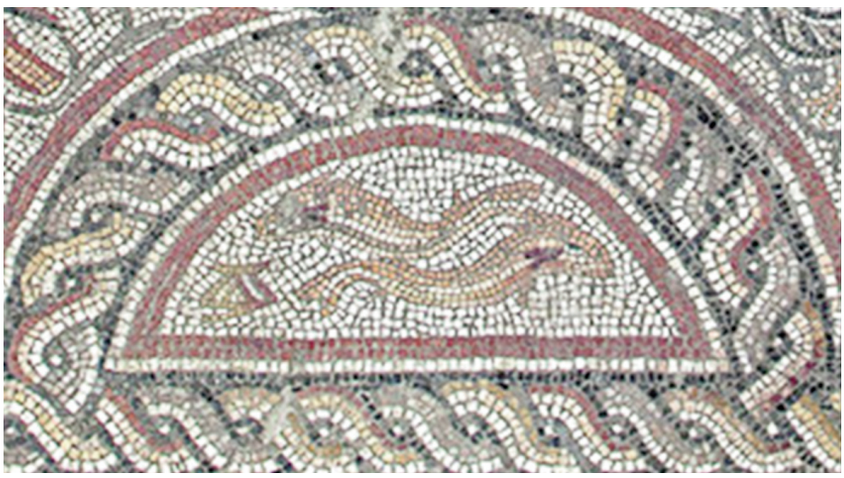
[26] Kim – Kim – Jang 2012, fig. 6.

[27] Nishibori 1960, 107. The blue component of the Aplysia ink has been identified as phycocyanobilin (MacColl et al. 1990).

[28] The Aplysia has a shell made primarily from aragonite (a form of calcium carbonate) deposited within a protein matrix (Carey et al. 2016, 143) with "consistency of a cardboard".

[29] Gorzalczany – Rosen – Sukenik 2020.





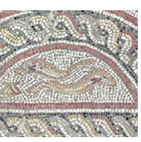


Fig. 4: The trap and two elongated fish in the mosaic of Lydda, Eastern Triclinium (Gorzalczany – Shoeff 2022, 151)

activity related to the purple Murex. They recognized species of the Muricidae family, as well as previously overlooked wicker traps. While the existence of a local purple Murex industry is uncertain, despite the Talmudic sources cited,[30] the mosaic's reference can be seen as an expressive reference to a source of wealth of its patron.

According to a traditional homily (TB *Megillah* 6a) on the biblical verse Deut. 33:19 (see also the so-called Targum Yonathan there), the gathering of *tekhelet* sea-snails was one of the blessed sources of economic wealth for the Zevulun tribe of seafarers. In contrast to purple dyeing, the production chain of the costly traditional *tekhelet* dyed thread from the *khilazon*, as well as its commercialization, apparently required a less elaborate infrastructure, but had to remain under ritual supervision (TB *Menakhot* 42b–43a). At the time of the mosaic's creation (late 3rd century – early 4th century CE), the traditional *tekhelet* was undoubtedly still in practice in Palestine. Contemporary evidence includes the skill of Germana, servant of Prince Judah II, as a *tekhelet* broker (TJ A"Z 2,9), the cited Amoraim opinions on proper tests to ensure the authenticity of *tekhelet* hue in TB *Menakhot* 42b–43a, or the episode in TB *Sanhedrin* 12a, where messengers from Tiberia to Babel, escaping the grips of the authorities, were able to deliver the precious *tekhelet* to the leading rabbinical figure Rava (d. ca 352). Given that Lod is referred to as "the city of *tekhelet* production" when it is identified with the Luz of TB *Sanhedrin* 12a in certain traditional[31] as well as scholarly[32] readings of this passage, one might well expect the Lod mosaic to also allude to the context of *tekhelet* activity.

Looking at the Lod mosaic in this perspective, I view as particularly suggestive the western half-medallion (Fig. 4) of the mosaic floor of the eastern triclinium uncovered[33] in the subsequent salvage excavation of 2018. Next to two specimens of an elongated sea creature, one finds an object in their vicinity, which seems to depict a basket trap.

Whereas a somewhat similar object in the main composition has been interpreted[34] as a wicker trap in the context of the Murex hunt, here, if these elongated fish actually represent the Aplysia mollusks, it becomes a reference to the net trap which would have been preferably used to catch the *khilazon* mollusk without harming it (cf. TB *Shabat* 74b–75a).

This direction of interpretation seems less far-fetched in the light of another contemporary iconographic source: a similar juxtaposition of representations in a painted room in the Jewish catacomb of the Villa Torlonia in Rome.[35] There, many of the representations feature Jewish symbols such as the Menorah chandelier, the Etrog citrus and the Shofar horn. Alongside these, there is an elongated sea creature – generally identified as a dolphin[36] – with a trident, and a curious trap-like object (Fig. 5) similar to that in the Lydda medallion.

Again, I find the proximity of the two objects significant, especially since, to our knowledge, there are no Muricidae snails or other fishy species in the entire pictorial composition of this catacomb fresco.

Conclusion

I am suggesting that, within the context of ancient Jewish traditional texts, the Aplysia is a valid outsider candidate for the source of the biblical *tekhelet*. On this basis, I propose that the Aplysia may be depicted in the Roman Lydda triclinium mosaic. Although my results are partial,[37] they are sufficient to warrant a review of the standard identification of Murex,

[30] In the argument of these authors, the quoted textual mention of Lydda as a town with a majority of dyers must be a misprint, as it does not appear in the Midrash Tankhuma text of the Rabbinical ruling referred to, which locates the said city of dyers "in the South". The inferred attribution of Lydda residence to the author of the ruling, R. Hoshaya, is barely more evident from the cited reference at the end of TJ Pe'ah. In fact, it is known from other texts that Rabbi Hoshaya founded a Yeshiva in Keisarin (e.g. TJ Terumot 10,2) and is found away from Lydda (TJ Demai 5,8). On the other hand, one could argue that "the South" sometimes refers to the vicinity of Lod (Mishnah Shevi'ith 9,2).

[31] e.g. Margaliot 1958, 25.

[32] e.g. Bokser 1963, 15.

[33] Gorzalczany 2018.

[34] Gorzalczany – Rosen – Sukenik 2020, 587.

[35] e.g. Hachlili 1998, 279–281.

[36] Hachlili 1998, 391.

[37] An issue not addressed here is the specific hue implied by this identification, as color experiments comparable to those of the Korean groups need still to be performed for the relevant local Aplysia species.

1	"גופו דומה לים"
2	"ברייתו דומה לדג"
3	"ועולה אחד לשבעים שנה ... לפיכך דמיו יקרים"
4	"חלזון נחש"
5	"מייתינן דם חלזון וסמנין ורמינן להו ביורה"
6	"מייתי חמירא ארכסא דשערי ואפיא לה בגוויה"
7	"שבק תנא דידן בישול סממנין דהוה במשכן ונקט אופה תנא דידן סידורא דפת נקט"

Fig. 5: The trap representation and neighboring elongated fish in the Roman Jewish catacomb composition (<www.catacombsociety.org/wp-content/uploads/2024/03/2215.jpg>; <www.beniculturaliebraici.it/wp-/CIMG0840.jpg>)

which has perhaps been too hastily also adopted for *tekhelet* cognates in other civilizations.[38]

Archaeology should ideally be able to solve the uncertainty, but in order to avoid methodological circularity, archaeological evidence for the actual *tekhelet* dye source should meet both the conditions of genuine archaeological and halakhic context. By halakhic context, I mean that a connection with the ritual *tekhelet* production chain or garment use should be established, which is, of course, challenging. While the chances of archaeomalacological confirmation of Aplysia in coastal industrial sites are poor, the ink dye spectral signatures of local Aplysia species should definitely be included as references in the analysis of relevant dyed archaeological artefacts.

[38] See e.g. Quillien 2019, 207.

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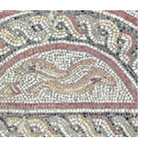

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