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## The biblical worms on Jonah's *Ricinus* were *Olepa schleini* larvae (Lepidoptera, Arctiidae)

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### Abstract

The behaviour and life history of the Israeli tiger moth, *Olepa schleini* WITT et al., 2005, that feeds on *Ricinus* is analysed and accords perfectly with the detailed description of a *Ricinus*-feeder mentioned in the Bible in the book of Jonah (4/7), demonstrating that the re-discovered and recently described moth is in fact Jonah's *Ricinus* worm.

### Introduction

Ancient peoples and civilisations showed a profound sensitivity for nature. All animals with possible harmful and beneficial impact on humans and their activities were studied in detail. This concerns not only the larger animals but also insects: In China, for example, the moth *Bombyx mori* was reared for silk production at least since 2700 BC. The interest in insects is also reflected by very early written descriptions of insect anatomy and metamorphosis by ARISTOTLE (384-322 BC) and PLINY THE ELDER (23-79 AC). The Bible also mentions many insects, e.g. locusts and grasshoppers (34 citations with ten different Hebrew names), moths (11 citations), and a great number of other insects, e.g. mosquitos (Diptera: Culicidae), horse-flies (Diptera: Tabanidae), ants (Hymenoptera: Formicidae), bees (Hymenoptera: Apis), and hornets (Hymenoptera: *Vespa crabro*). Some of these citations give quite accurate observations as in the subject of this paper.

### The mystery of the *Ricinus*-feeding worm in the book Jonah

**The story.** In the biblical book Jonah, there is a description of a *Ricinus*-feeding worm (Jonah 4)<sup>5</sup>: "So Jonah went out of the city [Nineveh] ...<sup>6</sup> And the Lord God appointed a castor oil plant [Hebrew: kikayon], and made it to come up over Jonah, that it might be a shade over his head, to deliver him from his distress. And Jonah was exceeding glad of the plant.<sup>7</sup> But God appointed a worm [Hebrew: tola'at] when dawn came up the next day, and it attacked [literally: beat] the plant, so that it withered.<sup>8</sup> And it came to pass, when the sun arose, that God prepared a vehement east wind, and the sun beat down upon the head of Jonah, so that he fainted (BIBLE, THE JERUSALEM BIBLE 1998).

**The history.** Some authors postulate the true historical existence of the prophet Jonah (BIBLE, NEUE JERUSALEMER BIBEL 1985:1032), dating back to the period of king Jeroboam II, 787-747 BC. The story is said to take place in Nineveh, in north-eastern Iraq, that was destroyed in 612 BC. The book of Jonah was most probably written down much later, in the 5<sup>th</sup> or 4<sup>th</sup> century BC (RUDOLPH 1971; BIBLE, NEUE JERUSALEMER BIBEL 1985; SIMON 1994; LAPIDE 2003). Other scientists date it to a period ranging from about 750 to 250 BC (COHN 1969; ZENGER 2004). The redactor of the book probably lived and was acquainted with nature in the area of present day Israel (RUDOLPH 1971; ZENGER 2004). The possibility of transferring Israeli natural phenomena to Nineveh in the story is stressed by RUDOLPH (1971) with the example of the hot eastern desert winds ('chamsin' or 'ruach kadim').

Of course, with both the shrub and the worm the book intends to express God's pedagogic response to Jonah's disapproval of the divine mercy shown to the repenting inhabitants of Nineveh. This does not

affect, however, the historicity or authenticity of the details presented. The book of Jonah may be an 'ironical novella' (STEFFEN 1994), but is surely based on historical material (STEFFEN 1994; LAPIDE 2003). Biblical texts are usually accurate in the description of natural phenomena (DRÖSCHER 1987) and there is no reason to think that the book of Jonah is an exception.

**Botanical interpretations.** There has been a controversy about the correct translation of the Hebrew word 'kikayon' since the time that Saint Jerome (HIERONYMUS, 342-420 AC) translated the Bible from Hebrew to Latin, to the writing of the 'History of Plants' by GERARD (1633), and to recent times. A few authors presumed that the shrub was a *Cucurbita* species (see e.g. RUDOLPH 1971). Similarly, English tradition usually translated it to 'gourd', and sometimes 'vine' (e.g. KING JAMES REFERENCE BIBLE 2005, NEW AMERICAN BIBLE 2005). However, most of the recent authors dealing with this problem (e.g. COHN 1969; RUDOLPH 1971; VANONI 1978; STEFFEN 1994; SIMON 1994; ZENGER 2004), which includes the majority of international Christian Bible translations, e.g. in France, Italy and Germany, and interpretation in Jewish bible science (e.g. MANDELKERN 1937; SIMON 1994), accept *Ricinus* as the correct translation of 'kikayon'. Jewish tradition on this goes back to the Babylonian Talmud (SIMON 1994). It is interesting to note that kikayon is also *Ricinus* in modern Hebrew botanical terminology (ZOHARI 1972).

**Previous zoological interpretations.** Unlike the interest in the 'kikayon', it appears that the specific identity of Jonah's worm ('*tola'at*') did not receive any attention among zoologists apart from some tentative interpretations as 'caterpillar' (RUDOLPH 1971; 'EASTONS BIBLE DICTIONARY' 2005). Though the Hebrew words for 'worm' ('*tola'at*', '*rimma*', '*sas*') may be used for many different kinds of animals, e.g. the purple snail, Purpuridae (MANDELKERN 1937), they usually refer to arthropod larvae in the bible (EASTONS BIBLE DICTIONARY 2005). The word '*tola'im*' (pl.) is used in the book Deuteronomium (28: 39) for a vine-feeding larva. There is, by the way, also general agreement that the gospel's (Matthew 6/19-20 and Luke 12/33) exhortation to 'have enduring treasure in heaven, where no moth ('*ash*') and no worm ('*sas*') destroys' refers to the adult and larval stages of the cloth moth, *Tineola bisselliella* (HUMMEL, 1823) (Lepidoptera: Tineidae) (EASTONS BIBLE DICTIONARY 2005).

### Description of the larvae of an Israeli tiger moth match all the details in the Bible

**A surprising, overlooked *Ricinus*-feeder in the Holy Land.** A spectacular species of tiger moth (Lepidoptera, Arctiidae) was found in Israel in 2002 along some ravines close to Tel Aviv. This pretty, colourful moth was unknown to science and it was described as *Olepa schleini* WITT et al., 2005. The other eight congeneric species are exclusively distributed on the Indian sub-continent. From mtDNA (COI) analysis, the southern Indian *Olepa toulgoeti* ORHANT, 1986 appears to be closest to it (WITT et al. 2005). Differences in 2.6 % of the nucleotides indicate that the Israeli population was formed by an evolutionary process rather than by human transport in historical times (WITT et al. 2005).

Larvae of the new Israeli species, like those of other *Olepa* species, feed on *Ricinus* in nature, and they refused to feed on other native plants in the laboratory (MÜLLER et al. 2006a).

**Previous data on *Ricinus* as host-plant for insects.** *Ricinus* is a very toxic plant and only one of the particularly toxic seeds may be a lethal dose for children (LOCHSTAMPFER 2005). The leaves are also toxic (HEBLING et al. 1996; ACACIO-BIGI et al. 1998) and leaf extract of *Ricinus communis* functions as an excellent insecticide (UPASANI et al. 2003; compare also CZAPLA & JOHNSTON 1990). HOLFELDER et al. (1998) found ricinine in the phloem sap and suggested that it serves as a 'feeding deterrent'.

With this background, it is not surprising that feeding on *Ricinus* has been recorded for very few species, e.g. one whitefly species, *Dialeurodes citri* (ASHMEAD, 1885) (Homoptera, Aleyrodidae), which feeds on a broad range of host-plants, mainly *Citrus*, and may exceptionally be found also on *Ricinus* (SOTO & GARCIA MARÍ 2005). There are many accidental records of Lepidoptera on *Ricinus* from the Nearctic, Neotropical, Indo-Pacific and Afrotropical regions (ROBINSON et al. 2005; SAVELA 2005), but in the western Palearctic region only four Lepidoptera species have ever been recorded feeding on *Ricinus*. From Egypt and Iraq, there are data on *Dysgonia algira* (Noctuidae), *Phycita diaphana* (Pyralidae) and *Phycita eremica* (Pyralidae), and European data refer to *Macdunnoughia confusa* (Noctuidae) (ROBINSON et al. 2005). Insect-feeding on *Ricinus* has never been recorded from Israel (Y. SCHLEIN & M.

ROTHSCHILD pers. comm.), except for the unpublished accidental finding of one single *Dysgonia algira* larva during very extensive monitoring of this plant (unpublished data of the authors). The scarcity of previous data and the exclusive feeding of *Olepa schleini* larvae on *Ricinus* under natural conditions (MÜLLER et al. 2006a) suggests that this species is by far the most likely candidate for the biblical 'worm'.

**Details in behaviour.** Larvae of *O. schleini* gather selectively on individual *Ricinus* shrubs and with their great numbers they cause extensive damage that may kill the plant in a short time (MÜLLER et al. 2006a). No other larvae are known to be so injurious to *Ricinus* and both *Phycita* species that infest this shrub in Egypt and Iraq (see above) are too small to cause severe damage. Also, in the book of Jonah the damage to worm-infested *Ricinus* was sufficient to cause an immediate withering (Jonah 4/7).

The original Hebrew text says, that the 'worm' was 'beating' the plant and brought it to wither (Jonah 4/7; MANDELKERN 1937; RUDOLPH 1971; SIMON 1994). This expression may refer to the very unusual behaviour of gnawing on stems and twigs of *Ricinus* that was typical of laboratory reared larvae (MÜLLER et al. 2006a) (Fig. 1). As far as is known, this unique behaviour is not shared by any other *Ricinus*-feeder in the world.

The 'worm' in the book of Jonah was feeding before sunrise (Jonah 4/7). Larvae of *O. schleini* are nocturnal, extremely photophobic and feed only at night. At dawn, they leave the tree or shrub and hide in the litter and dry leaves on the ground in the vicinity of the trunk. It is interesting to note that this behaviour is also induced by artificial light at night (MÜLLER et al. 2006a). This is the reason why the 'worm' that infested Jonah's *Ricinus* was not seen after dawn, and that it was said to kill the plant 'overnight' (Jonah 4/10).

**Why has this *Ricinus*-feeder been overlooked for such a long time?** There is a gap of 2500 years between both observations. This fact raises several questions. Is it possible, that *O. schleini* colonized Israel recently? The mtDNA analysis contradicts the possibility of a recent invasion or transportation by man of a known Indian species in historical times (WITT et al. 2005).

How could such a species be continuously present without being observed and mentioned in the literature? For hundreds of years, no serious scientific investigation of Lepidoptera from the Holy Land had been undertaken. After the first but very incomplete list of Lepidoptera (AMSEL 1933), no comprehensive studies were done until cooperation was started between the Nature Reserves and National Parks Authority of Israel, Tel Aviv University, Museum Witt and Zoologische Staatssammlung München in 1987. In the run of this project, 15 years of extensive monitoring were necessary to discover this moth. Possibly, in the last century, due to the alteration of habitats in the Coastal Plain of Israel, the species has suffered a severe decline in abundance (MÜLLER et al. 2006b).

## Conclusion

*Olepa schleini* is the only insect which regularly infests *Ricinus communis* in the homeland of the redactor of the book Jonah. The aggregation of larvae on particular trees, with the unusual feeding that includes the stems, causes massive damage and withering of this plant. All this and the diurnal hiding of larvae on the ground are in perfect agreement with the biblical description of the 'worm' that destroyed Jonah's shrub overnight. We therefore conclude that *O. schleini* is the 'worm' mentioned in Jonah book 2500 years ago.

## Zusammenfassung

Die Lebensweise des neu entdeckten, *Ricinus*-fressenden Bärenspinners *Olepa schleini* WITT et al., 2005 aus Israel wird analysiert und mit der detailgenauen Beschreibung eines an *Ricinus* schädlichen 'Wurmes' in der Bibel (Buch Jona 4/7) verglichen. Die vollkommene Übereinstimmung beider Merkmalsätze zeigt, dass 'Jonas *Ricinus* Wurm' in der Tat Raupen dieses Bärenspinners waren.



**Fig. 1.** *Olepa schleiini* WITT et al. 2005. Larva feeding on stems of *Ricinus*.

### Acknowledgements

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