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WHAT WAS MANNA?

By Roger S. Wotton

Following their release from Egypt after the 10 Plagues, the Israelites spent some time wandering in the wilderness. They were sustained there by a special food called manna. If we take a literal view of The Bible, we can acknowledge that manna was a physical entity with supernatural origins that fell from the sky. We can assume the accuracy of recall by observers, the accuracy of repetition of the original manna story, and the accuracy of exegesis by scholars who have interpreted the later written accounts over hundreds of years. On the other hand, we could suggest that manna was described inaccurately, that it has been embellished by myth and the mistaken translation of texts. In this essay I will attempt to discuss manna as a natural substance, using the literal Biblical text as my guide.

Origins of materials that fall from the sky

Before considering manna we should look at other materials that fall from the sky, and their origins. We are all familiar with terrestrial objects flying through the air on windy days. Leaves and other vegetation are blown away by winds and, in severe storms, we can be swept off our feet, although our size prevents us from being carried far. Smaller objects are, however, transported a long way. Tiny mineral grains are carried tens or hundreds of kilometres, sometimes drying from raindrops to leave distinctive pink, yellow or brown spots on shiny surfaces. In the UK, these mineral grains may originate as far away as the Sahara Desert, where they were swept up in dust storms.

Not all objects carried by winds have terrestrial origins. Venture to any coast during a storm and you will be covered with sea spray, which leaves a salty coating on the face and lips. Such aerosols can be generated easily in the laboratory by blowing on the still surface of a tank of water. A sheet of glass held above the water surface soon becomes covered with droplets. We know that the aerosols we exhale when sneezing contain many microscopic organisms; the same is true of aerosols blown off the surface of natural water bodies. It is probably a key means of transmitting some diseases - *Legionella* bacteria (that result in legionnaire's disease) provide a very good example. These bacteria come from a community of organisms living at the surface of natural water bodies. They utilise materials that do not mix with water, thus accumulating at its surface. Micro-organisms and organic matter at the water-air interface also provide food for more casual visitors to this microhabitat, such as tadpoles and some kinds of fish.

Animals that fall from the sky

A report entitled 'Sky "rains tadpoles" over Japan' appeared in the Daily Telegraph in June 2009[1], highlighting the latest example of animals falling from the sky. These tadpoles came from shallow ponds or lakes and, as the article suggests, were swept up by water spouts that rise, like mini-tornadoes, from circulating air and updrafts. Officials at a meteorological observatory in Japan 'told local media that they were unsure how the tadpoles had arrived there as there had been no reports of strong winds at the time'. However, the tadpoles would have been picked up some distance away from the site of their re-appearance and transported within clouds. We know that strong air currents may occur in clouds, and that these are sufficient to support small objects and carry them over distances as the clouds are swept along. When winds abate, the objects fall, especially given the occurrence of rain; fishes can also appear in this manner. Such events may give rise to many local theories and myths.

What other materials are transported from the water surface by winds? McAtee[2] reports falling jelly, citing Moreau de St Méry's observation that:

> From November 1785 to the 5th of May 1786 there was experienced a terrible drought. The last day viz. May 5 1786 there fell during a strong east wind, in several parts of the city of Port au Prince, a great quantity of black eggs which hatched the following day. M. Mozard preserved about 50 of these small animals in a flask half full of water where they shed their skins several times…They resembled tadpoles…

Could these tadpoles have hatched from frog spawn that had been carried up into clouds, protected by their coatings of jelly? Or, given that moulting was seen to occur, were these animals really larval midges? Midge eggs are laid in mucilaginous masses, which McAtee acknowledges in his paper to be a source of 'jelly rains'. It is also worth noting that Moreau de St Méry reports the arrival of the black eggs after a strong east wind. This suggests that they arrived in falling rain, rather than in rivulets resulting after heavy rainfall.

The Biblical account of the provision of manna

Could manna have been carried by winds in this way? If so, what was this substance? The following excerpts from the King James's Bible[3] provide the following accounts:

> *Exodus 16*
> 1. And they took their journey from Elim, and all the congregation of the children of Israel came unto the wilderness of Sin, which is between Elim and Sinai, on the fifteenth day of the second month after their departing out of the land of Egypt.
> 13. And it came to pass, that at even the quails came up, and covered the camp: and in the morning the dew lay round about the host.
> 14. And when the dew that lay was gone up, behold, upon the face of the wilderness there lay a small round thing, as small as the hoar frost on the ground.
> 15. And when the children of Israel saw it, they said one to another, It is manna: for they wist not what it was. And Moses said unto them, This is the bread which the LORD hath given you to eat.
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> 20. Notwithstanding they hearkened not unto Moses; but some of them left of it until the morning, and it bred worms, and stank: and Moses was wroth with them.
> 21. And they gathered it every morning, every man according to his eating: and when the sun waxed hot, it melted.
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> 31. And the house of Israel called the name thereof Manna: and it was like coriander seed, white; and the taste of it was like wafers made with honey.
> 32. And Moses said, This is the thing which the LORD commandeth, Fill an omer of it to be kept for your generations; that they may see the bread wherewith I have fed you in the wilderness, when I brought you forth from the land of Egypt.
> 33. And Moses said unto Aaron, Take a pot, and put an omer full of manna therein, and lay it up before the LORD, to be kept for your generations.
> 35. And the children of Israel did eat manna forty years, until they came to a land inhabited; they did eat manna, until they came unto the borders of the land of Canaan.
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> *Numbers 11*
> 5. We remember the fish, which we did eat in Egypt freely; the cucumbers, and the

melons, and the leeks, and the onions, and the garlick:
6. But our soul is dried away: there is nothing at all, beside this manna, before our eyes.
7. And the manna was as coriander seed, and the colour thereof as the colour of bdellium.
8. And the people went about, and gathered it, and ground it in mills, or beat it in a mortar, and baked it in pans, and made cakes of it: and the taste of it was as the taste of fresh oil.
9. And when the dew fell upon the camp in the night, the manna fell upon it.

Psalm 78
24. And had rained down manna upon them to eat, and had given them of the corn of heaven.
25. Man did eat angels' food: he sent them meat to the full.
26. He caused an east wind to blow in the heaven: and by his power he brought in the south wind.
27. He rained flesh also upon them as dust, and feathered fowls like as the sand of the sea:
28. And he let it fall in the midst of their camp, round about their habitations.
29. So they did eat, and were well filled: for he gave them their own desire;

Psalm 105
29. He turned their waters into blood, and slew their fish.
30. Their land brought forth frogs in abundance, in the chambers of their kings.
31. He spake, and there came divers sorts of flies, and lice in all their coasts.
32. He gave them hail for rain, and flaming fire in their land.
33. He smote their vines also and their fig trees; and brake the trees of their coasts.
34. He spake, and the locusts came, and caterpillers, and that without number,
35. And did eat up all the herbs in their land, and devoured the fruit of their ground.
36. He smote also all the firstborn in their land, the chief of all their strength.
37. He brought them forth also with silver and gold: and there was not one feeble person among their tribes.
38. Egypt was glad when they departed: for the fear of them fell upon them.
39. He spread a cloud for a covering; and fire to give light in the night.
40. The people asked, and he brought quails, and satisfied them with the bread of heaven.
41. He opened the rock, and the waters gushed out; they ran in the dry places like a river.

Verses 29 – 36 of Psalm 105 recall the Ten Plagues of Egypt, most of which may have natural explanations[4]. Whether natural or supernatural, the Ten Plagues had a profound effect on the Egyptians, resulting in the release of the Israelites and the commencement of their migration into the wilderness. The Biblical account of the Ten Plagues describes dramatic changes in weather and in the population densities of both plants and animals[4]. As the provision of manna commenced about six weeks later, it could have been influenced by these same weather systems.

The historical view of manna

What has been the historical view of the provision of manna? Paintings depict how the events described in The Bible were perceived many centuries ago. Not surprisingly, there is much artistic licence on what is portrayed and no consensus on the interpretation of the texts. For example,

The Master of the Manne (1470)[5] and The Master of the Holy Blood (c. 1520)[6] depict manna falling from the sky being collected in baskets. In these interpretations, manna is seen in the form of discrete but irregular lumps, a little like field mushrooms, and whitish in colour. Tintoretto (c. 1577)[7] shows manna falling, but with little gathering by the Israelites; the composition and artist's demonstration of artistic skill seem to be the main reasons for this work. In contrast, there is no evidence of manna at all in the paintings by Bacchiacca (1540-1555)[8] and Poussin (1640s)[9], as everything is centred on allegory. Dieric Bouts the Elder (1464-7)[10] depicts the act of gathering, but any evidence of the physical nature of manna is lacking. Perhaps manna is present in the latter three paintings but is invisible as it is brownish in colour?

Reviewing the evidence for manna

What do we know about manna and the environment at the time it was present? The following summary is made from the Biblical account.

1. After dew fell in the wilderness, a covering of small objects remained (Exodus 16, Numbers 11). Manna rained down after dew. It was a time of strong winds from the east and from the south (Psalm 78).
2. Manna was similar in size to coriander seeds (Exodus 16, Numbers 11) and tasted like wafers and honey (Exodus 16). (My measurements suggest that coriander seeds mostly range from 3 – 5 mm in diameter).
3. Manna was white but also coloured like bdellium – a yellowish-brown exudate from trees (Numbers 11). Did the colour white refer to the interior of each piece?
4. Manna could be ground and baked into oily cakes (Numbers 11).
5. Manna could be stored for long periods of time, yet it was colonised by 'worms' and decomposed if left in the open. It also melted in direct sunlight (Exodus 16).
6. The re-emergence of water in streams after dry conditions (Psalm 105) may have been connected with pronounced changes in the direction of winds (Psalm 78).
7. In addition to manna, quails were present (Exodus 16, Psalm 105).

What were quails feeding upon?

Quails are migratory birds, the current distribution of the common quail (*Coturnix coturnix*) extending over a wide area. Some populations migrate to sub-Saharan Africa in autumn and return north in spring, landing in Sinai and the Nile valley to feed before flying across the Mediterranean. The quails described in the Biblical texts are probably these migrants[11,12] but what were they feeding on if food was in short supply? The usual diet of quails consists of plant matter and seeds, but they also consume larval and adult insects. Perhaps their food was scattered and difficult to collect or process by humans, or there may have been lingering insects from the huge numbers of 'lice', 'fleas', 'pestilence' or 'smut'[4] surviving from the population explosions of the Ten Plagues? Or perhaps they were feeding on manna?

Explanations of manna from earlier sources

Manna is described both as falling from the sky and appearing after dew. We know that materials are carried into the air, and the mention of dew suggests that the fall of manna coincides with humidity. Perhaps manna may be the fruiting bodies of fungi (which can appear rapidly in favourable conditions); this may have been the inspiration for the manna in paintings like those of The Master of the Manne and The Master of the Holy Blood. However, are fungi likely to have been lifted into the sky when their fruiting bodies are attached to the underground threads of mycelia?

Bodenheimer[13] records that manna has been regarded as a lichen, *Lecanora esculenta*, which forms 'pea-sized globules which are light enough to be blown around by the wind'. Some may be the size of coriander seeds. These sweet globules are gathered by peoples from the High Atlas to Central Asia, but never in large quantities. Bodenheimer[13] also states that *Lecanora* has been completely absent from the 'region of Sinai during the last 150 years when many collections of rock lichen were made'. It is likely, however, that the climate at the time of the escape from Egypt was rather different to that of today, so the current absence of the lichen may result from recent climate change.

Manna has also been associated with tamarisk thickets characteristic of some wadis in Sinai[13]. Wadis are dried water courses that only flow as streams after rainfall; we know that there were rains at the time of the biblical manna. Bodenheimer[13] describes exudates (from pinhead to pea-sized) found on tamarisk during the growing season, explaining that the quantity of these exudates varies with rainfall. They may thus have been in good supply, prompting the Isrealites to camp near wadis as water was essential for survival. The origin of the exudates is not likely to be the trees themselves, but insects that are found on the growing shoots. Like aphids, these insects take up plant sap, utilise proteins and exude excess carbohydrates in the form of honeydew.

The explanation of manna as honeydew is convincing, but how, then, could it have 'rained down'? Did this phrase denote the presence of manna in figurative terms, or did it suggest that manna fell from trees? In the case of the latter, how could it have fallen in quantities that could have been gathered? Place any object under a silver birch tree in spring and summer and it will rapidly be covered with sticky drops of honeydew produced by birch aphids. These spots become blackened after colonisation by micro-organisms and the adhesion of mineral grains and dust. Although coloured, these spots look nothing like seeds; such honeydew is hardly collectible. However, ants collect honeydew from aphids and often return this valuable food to their nests; they also gather the sweet secretions exuded by plants when damaged by insects[14]. Could, then, the 'seeds' of biblical manna actually be ants having crops bloated with honeydew that are then shaken or blown from trees?

Sweet substances from *Fraxinus ornus* ("Manna Ash") are collected by locals in Iraq and Iran[15]. The leaves of the Manna Ash produce sticky secretions when attacked by insects, and it is likely that exudates from the insects are also included in the mass (cf. Davidson[16]). Fallen leaves are collected and boiled in water to extract the mixture of sugars on their surface, the resultant solution being 'mixed with eggs to make a popular dessert'.[14] As this manna is stuck to tree leaves, it does not fit in with the Biblical description, yet it echoes the bdellium described in Numbers 11 verse 7.

Gaz of Khunsar ("manna of Iran") is collected from the shrub *Astragalus adscendens*, typically in gullies on northern slopes that become snow-covered in winter[17]. The producer of this sugary secretion is a psyllid plant bug. Gaz is harvested by beating the shrubs and collecting the falling materials into a container made from a loop of wood covered with leather. It is a commercial product and is subject to government licence. Like other exudates from bugs, the secretion is rich in sugars and it is used to produce a kind of nougat, with the addition of egg white, nuts and other ingredients[17]. As with other honeydews, it seems not to 'rain down', but must be collected from leaves.

New explanations for manna

The theory that manna is lichen or comes from plants and their associated insects suggests a local source of the material, not one that originated over distances. I would like to offer some new explanations for the case of manna originating from a more distant land (or water surface,

later to fall from the sky).

Arthospira spp. are multicellular, filamentous and coiled cyanobacteria (blue-green algae) that grow in profusion in the surface waters of some lakes. They photosynthesise like plants and produce carbohydrates from carbon dioxide and water. Some carbohydrates are then transformed into other important biological molecules by the uptake of nitrogen and phosphorus from the surrounding water. These cyanobacteria are given the common name Spirulina and are grown commercially in large, shallow tanks and channels in several countries, including the modern state of Israel[18]. The cyanobacteria are removed once they have achieved high densities, and are then processed and packaged, usually as dried powders or tablets. They are a source of proteins, carbohydrates, vitamins and other valuable food supplements.

Ciferri[18] describes natural populations of Spirulina that form mats at the water surface, which can be collected and dried in the sun, a practice that can be found around the shores of Lake Chad in sub-Saharan Africa. Cakes result which 'without any further treatment, represented Dihé, [an] object of some commerce in the local markets'[18]. The drying process reduces the numbers of harmful bacteria, the resultant cakes providing a source of valuable and nutritious food. Another type of Spirulina is found in Central American lakes where it, too, is gathered for food. The paper by Ciferri[18] contains a copy of a 16th century map which shows people harvesting Spirulina mats from a Mexican lake. In addition to the collection of material from the water, we also see men raking material from the lake's edge, where the cyanobacteria have been stranded by the decreasing water level as the lake dries. It does not require much imagination to see that drying Spirulina mats and fragments can be swept up by wind. Could these be the source of manna?

In aquaculture, Spirulina tanks, or streams, need to be agitated to stop the formation of cyanobacterial mats, but too much agitation results in foams at the water surface. The foams consist of broken cells as well as exudates from the living Spirulina. Cyanobacteria produce large quantities of these exudates and they contain carbohydrates, proteins and other organic chemicals[19]. Masses of foam can form on water bodies as the water surface is whipped up by winds, meaning that the foam can then easily be blown away. What if the manna falling from the sky was really the foams produced by cyanobacteria? This would fit the description of manna coming from the sky. The manna might dry into small globules that pick up a coating of soil and organic matter, thus appearing brown. These globules would also appear to melt in the sun as the myriad bubbles in the foams burst. The foams contain carbohydrate so they are likely to be sweet and they can also be stored in dried form. The 'worms' that feed on them may be aquatic insect larvae that were incorporated into the mass and also blown away from the water surface. These foams are likely also to decompose, but this is less likely if they consist mainly of carbohydrate (as are the foams originating from the exudates of some green algae). Storing the dried foam would be like keeping flour and sugar in open bowls.

Foams from cyanobacterial, or algal, exudates could come from both marine and freshwater sources. The Israelites wandered between Elim and Sinai, so they were not far from either the Red Sea or the Mediterranean. They must have had a source of drinking water that may have been wadis, or ponds and pools formed after rainfall (a typical habitat exploited by Spirulina, which cope well with the high concentrations of salts often present in drying water bodies). Just as with the appearance of quails, one of the problems in interpreting the environmental conditions and landscape likely to be faced by the Israelites is that we tend to assume that conditions in the region were identical to those of today. However, we know that there have been large changes in climate over time, and the idea of 'wilderness' may be relative, in contrast with the fertility of the regions the Israelites had left in northern Egypt. There is also the likelihood of unusual winds and rains just before (and possibly during) the migrations[4].

If there were ponds and streams near the settlements of the Israelites, could manna be the bodies of aquatic insects? Swarms of dancing midges swirl around markers near lakes and ponds; the markers might be trees, or buildings, and swarms have been referred to as 'smoking chimneys' as hundreds of thousands of insects form each swaying column above the marker. These midges do not bite, but they can be present in such large numbers so as to cause a considerable nuisance. They are a food source in some countries.[20] For example, the Rift Valley lakes of Africa have large swarms of non-biting midges that are collected and made into Kungu cakes[21]. According to Bergeron et al,[22] the insects are collected from swarms and then dried and ground to produce flour, which is mixed with water, then dried to form cakes. The numbers of insects are so large that Kungu cakes are piled at market stalls, waiting to be sold.

But what has this to do with manna? Swarms are characteristic of days with gentle winds, but what happens during the emergence of these insects from the water surface when winds are blowing strongly? It is likely that they will be carried with the materials blown off the water surface, then deposited elsewhere, either during rains or when the wind dies down. They are likely to be damaged as a result, their legs frequently broken off. The insect bodies, which resemble seeds, are brown. They can be collected, dried, and ground, and the resulting flour is nutritious[22]. Although I have not eaten Kungu cakes, I have eaten aquatic insects and can confirm that they have an oily taste, just as has been described of manna. They can even taste slightly sweet.

Southerly winds are mentioned in Psalm 78. Why would this change in wind direction be noted unless it was an unusual or large-scale event? Could these winds (different to the regular, contemporary Khamsin[23]) have brought midges from the Rift Valley lakes so that the Israelites were preparing their own version of Kungu cakes? Could insect bodies also have provided food for quails, coming to land after strong winds abated?

Imaginative views of manna

Manna is, inevitably, subject to speculation and conjecture. In addition to the variety of representations of manna in painting and the development of ideas that have become commonplace due to repetition in texts there is the extension of ideas on the nature of manna into areas relating to religious mysticism. A quote from Merkur[24] provides a good example:

> [T]he biblical story of manna received its distinctive interpretation among Jewish and Christian exegetes who recognised the relevance of manna to the practice of visionary mysticism. More precisely, by stating that when the Israelites ate manna they envisioned the glory of God, the Bible plainly and openly claimed that manna was what we would today call 'psychoactive'. Eating manna facilitated the occurrence of a vision, and many prominent Jewish and Christian religious authorities over the centuries have secretly shown that it did so.

Is that going a little too far? It is adding a supernatural element to what was most likely a natural process with theistic interpretations. As Davidson states, 'the manna of the 16th chapter of Exodus is a miraculous food, intended not only to sustain the Hebrews during their wanderings in Sinai, but to teach faith and obedience'.[16]

Manna and the accuracy of the Biblical account

There is no rational explanation that fits all the details in the Biblical record. We are thus faced with a quandary. If we take the Bible literally, then we must accept that manna rained down as a result of instantaneous creation, or transformation, of matter by a supernatural force. This

requires religious faith.

If, in contrast, we seek a rational approach to the description of manna, there is no single explanation that fits the details given in the Bible. Perhaps none of these events took place? If they did, it appears that we must either accept that supernatural events occurred or that the Bible cannot be taken as a literal account. The latter view leads to a problem, as we then have to select which parts of The Bible are accurate and which are symbolic, or poorly recalled. This conflict has taxed scholars, especially believers, for many hundreds of years and will continue to do so.

Division of Biosciences

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