

## Yellow fever in Swansea, 1865

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### SUMMARY

A cargo of copper ore from Cuba was discharged at Swansea in mid-September 1865, during a spell of exceptionally hot weather. A small number of mosquitoes infected with the yellow fever virus, disembarking at the same time, established an epidemic of yellow fever in the town. In the next 25 days, at least 27 inhabitants were infected and 15 of them died. The quality of contemporary observation and recording has encouraged a re-examination of the events in the light of knowledge unavailable at the time. It cannot be assumed that the episode will not be repeated.

### INTRODUCTION

At midday on 9 September 1865, a seaman died of yellow fever (YF) 3 h after being put ashore in Swansea. Thirteen days later on 22 September, a resident of the town died of the same disease. Learning of this the next day, the Registrar of Births and Deaths notified the Registrar General in London, who in turn informed the Office of the Privy Council. As a result, Dr George Buchanan was instructed to go to Swansea to conduct an investigation. This he did between 27 September and 5 October, and his account of the outbreak, dated 25 October, is appended to the Medical Officer to the Privy Council's Annual Report for 1865 (Buchanan, 1866).

### THE OUTBREAK

The barque 'Hecla', a wooden sailing vessel, left Cuba for Swansea with a cargo of copper ore on 26 July, 1865. She sailed leaving behind one seaman dead of YF, and another in hospital. On board were four officers, ten seamen and two passengers. During the voyage home, three of the crew were buried at sea, their deaths recorded as due to YF. Two others who had suffered from fever were recovering on arrival in Swansea. A sixth, James Saunders, had fallen ill on the 27 August. Despite this history, the master did not raise a quarantine flag on entering the Bristol Channel, where he took on board a pilot and some additional seamen to assist his depleted crew work the vessel into port. The 'Hecla' tied up in the North Dock (since filled in) at 9.0 a.m. on Saturday, 9 September. The sick man, said to be suffering from dropsy, was lowered over the side and taken to a lodging house. Before he died 3 h later he had been seen by three doctors (all of whom diagnosed YF), and by the town's Mayor.

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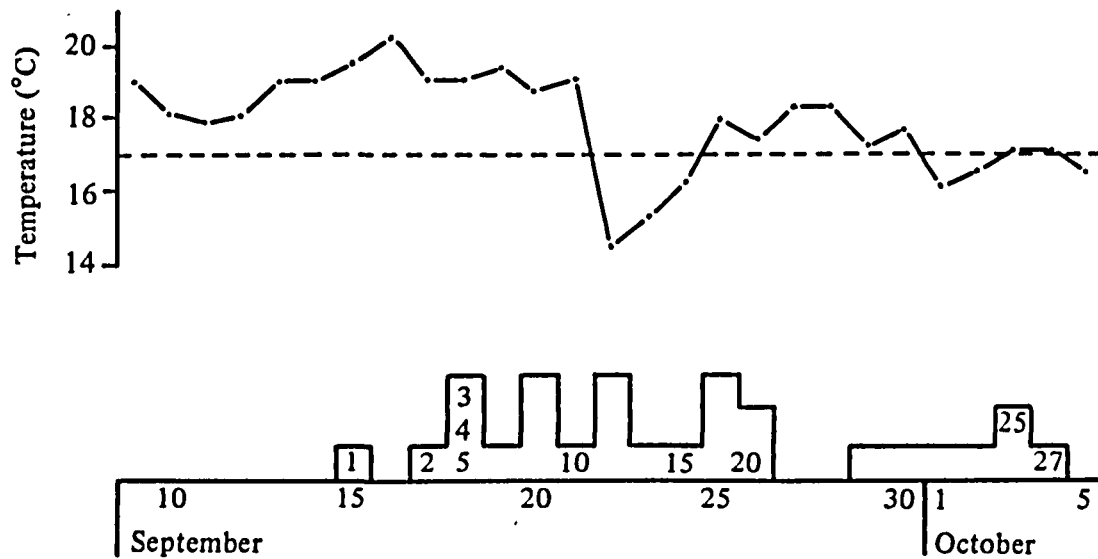


Fig. 1. The epidemic curve of the outbreak of yellow fever in Swansea in 1865. Individual cases are numbered serially by the date of onset of illness. The mean shade temperature is superimposed: the interrupted line at 17 °C is the temperature at which *Aedes aegypti* becomes inactive. The infected mosquitoes were imported on the 'Hecla' which docked on the 9th and began effective unloading on 13 September.

In the meantime the passengers and crew of the 'Hecla' had dispersed, and unloading had commenced. Saunders' death led to questions which quickly revealed the true history of the voyage, and a series of public health measures were put into effect. The corpse, shrouded in a tarred sheet, was buried at once, and his bedding and clothing were destroyed. The room in which he died was disinfected with limewash and chloride of lime. The Sanitary Inspector together with Mr Evans, lecturer in chemistry at the Normal College in Swansea, were sent to fumigate with chlorine the 'clothes, rooms and persons' of the passengers and crew of the 'Hecla', who had been located by the police. The unloading of the 'Hecla' was stopped on the afternoon of her arrival; she was closed up, and 'purified' with chloride of lime for the next 3 days. Unloading recommenced on 13th, and was completed by the 21 September.

A ships' rigger who was working on a vessel close to the 'Hecla' boarded her briefly on 9 September. Six days later (on the 15th) he fell ill, and was subsequently diagnosed as suffering from YF from which he recovered. The second local resident to fall ill was a customs officer whose death precipitated Dr Buchanan's investigation. The outbreak then developed in time as shown by the epidemic curve (Fig. 1) and in space as depicted in the plan (Fig. 2).

At least 27 people were infected, and 15 died (Table 1). Although a formal definition was not given in the Report, it is clear that to be included as a certain case of YF, patients had to be severely prostrated, to be jaundiced, and suffer gastro-intestinal haemorrhage. Twenty-two fell into this category, and 15 of them died. Another seven were diagnosed as cases of YF with less certainty. The detailed case histories given in the Report make it clear that these were not so severely ill; none of them died. Two members of this group, whose diagnoses were acknowledged at the time as being most improbable, have been excluded here. One of them died suddenly without clinical evidence of YF, the other, a doctor, suffered

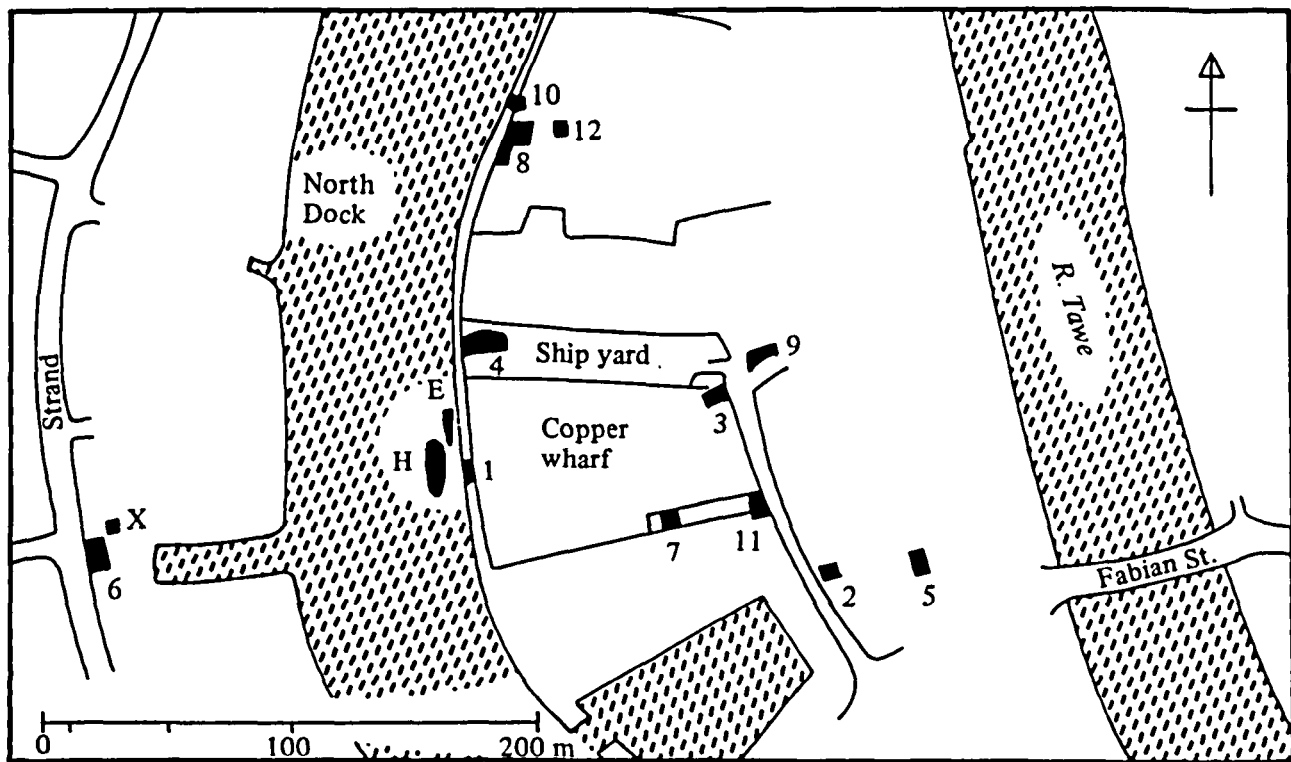


Fig. 2. A plan of part of the port of Swansea, depicting the distribution of cases during the 1865 outbreak of yellow fever. Fabian Street (now Fabian Way) and the Strand still exist. The North Dock has been filled in. (Redrawn from Buchanan, 1866.) Key: H, the 'Hecla'; E, the 'Eleanor' (cases 20, 24); x, the lodging where the seaman died on 9th September. The locations of the supposed sites of infection of indigenous cases are numbered and cross-referenced according to the list below to the individuals who were attacked in each of them, as indicated in Fig. 1. Fatal cases are in italics.

Location	Associated cases	Location	Associated cases
1	1, 2	7	8, 13, 15, 22, 25
2	3	8	9, 10
3	4, 14	9	12, 16, 17
4	5, 19, 26	10	18
5	6	11	21, 27
6	7, 11	12	23

an ill-defined illness that might have been atypical mild YF, but with an apparent incubation period of only 2 days.

All the classical signs and symptoms of YF were recorded repeatedly among the case histories that are given in some detail in the Report. The onset was typically very sudden, with severe headache and pain in the epigastrium, loins, back and legs. Fever, nausea and persistent vomiting were universal. After 3 or 4 days there was often an apparent remission, followed by the development of a toxic phase with jaundice, relative bradycardia and haemorrhages. The latter involved the gut in particular, with characteristic coffee-grounds or dark vomit, and black stools. Oliguria was often noticed. In more severe cases patients became delirious or lapsed into coma. Those that died did so, on average, on the fifth day of illness, with a range between 2 and 10 days. It cannot be doubted that the condition described was indeed YF, though of course at that time the diagnosis was made entirely on clinical grounds.

Table 1. *Summary of morbidity and mortality in the outbreak of yellow fever (YF), Swansea, 1865*

	Males	Females	Totals
YF	13	9	22
Died	8	7	15
Probable YF	1	4	5
Died	0	0	0
Total ill	14	13	27
Died	8	7	15

During the period, '...almost tropical heat prevailed at Swansea...'. To support this, the Report tabulates the sun and shade temperatures with records of former years for comparison. The means of the maximum and minimum daily shade temperatures given for the period of the outbreak have been included in Fig. 1.

#### DISCUSSION

Communicable disease epidemiology grows in interest with the number of biological cycles involved in each case. YF has a complex epidemiology, with a primary vertebrate – mosquito – vertebrate cycle into which man intrudes by accident, and a secondary man – mosquito – man cycle. The beginning of a classical outbreak of urban YF depends on the vector, *Aedes aegypti*, taking a blood meal from a patient in the viraemic stage of the disease. This extends from just before the onset of illness for 3–5 days. After the infected blood meal there follows an extrinsic incubation period (EIP), at the end of which the mosquito can transmit the infection to its next victim, and so on for the rest of its life. Following an incubation period of 3–6 days this next human victim becomes the source of virus for more mosquitoes, with a considerable potential for amplification as stage succeeds stage.

The EIP varies with the ambient temperature, being 4 days at 37°, 11 days at 23° and 36 days at 18 °C (Davis, 1932). *A. aegypti*, and particularly its New World variant, is heavily oriented towards the human species, preferring to feed on man, and being well adapted to live and breed in his environment. It usually bites by day, and may feed on alternate days. It tends to loiter in the locality of its food supply, flying short distances from house to house only when necessary, although marked individuals have been found as much as 1000 m from a point of release. As a tropical species it is most active between 25 and 30 °C and it becomes increasingly somnolent as the temperature falls; it is said to cease biting and stop moving when the temperature drops below 17 or 18 °C. It does not breed if the night temperature is below 20 °C. The female lives perhaps 30 days in the wild, though survival of an infected mosquito for 154 days has been recorded (Riley & Johannsen, 1938; Matheson, 1950).

In the last century, YF was not uncommon among seamen visiting and returning from the epidemic and endemic areas of the Caribbean and the tropical and sub-tropical coasts of North, Central and South America. Because of the time taken to cross the Atlantic, most were buried at sea, or had recovered before arriving

in Europe. From time to time infected mosquitoes that had boarded a vessel at the point of departure must have survived the crossing or, if they had been hatched on board, have become infected after feeding on a sick seaman. Despite such importations, YF acquired in Britain has been recorded rather rarely, probably because the ambient temperature is normally too low for *A. aegypti* to bite, much less breed. The 1865 outbreak seems to have been the largest, with other incidents reported involving single rather doubtful cases in Swansea in 1843, 1851 and 1864 (Buchanan, 1866) or small numbers in Southampton in 1866 and 1867 (Anon., 1866, 1867; Medical News, 1867). The latter apparently did not spread beyond passengers and crew of vessels who were ill or died on board while in quarantine after arrival in the Solent.

YF was endemic in Cuba between 1762 and 1901 (Van Rooyen & Rhodes, 1958). In the second half of the nineteenth century Cuba was the source of some of the copper ore needed to supplement that mined in Britain (chiefly in Devon and Cornwall) during the industrial revolution. At the time, Swansea was the principal centre for the smelting of copper ore.

In September 1865 not only did some Cuban ore arrive in Swansea, but it was accompanied by YF-infected mosquitoes, which most unusually found the temperature to their liking. Allowing for the incubation period of 3–6 days, the first indigenous patient was probably infected by a bite on board the 'Hecla' on 9 September, the second on the neighbouring dockside between 11 and 15 September, and the remainder by mosquitoes that fanned out from the barque to a maximum range of 200 m when they were disturbed by the unloading that started in earnest on 13 September. On 22 September the average shade temperature suddenly fell by 9 °C, remaining below 17 °C for 3 days before rising briefly once more to over 18 °C. The short intermediate cool spell probably caused the break in transmission responsible for there being no new cases on 27 and 28 September (Fig. 1).

A circle of 50 m radius drawn round the 'Hecla' (Fig. 2) contains no houses, but includes the sloop 'Eleanor'. This small vessel was moored alongside the 'Hecla' from 16 to 18 September, when she sailed for Llanelli. In the days after she arrived there on 22 September two cases of YF were diagnosed among her crew. The dates of onset of disease were such that the patients were bitten by an infected mosquito during the voyage, or after entering port. The mosquito concerned must have transhipped while the vessels were in proximity in Swansea. In addition to the two cases on the 'Eleanor', it is clear that five other patients (locations 1 and 4, Fig. 2) contracted YF within 50 m of the 'Hecla'. All these seven were males whose work brought them into the area.

A second circle of 50 m beyond the first includes 2 neighbouring occupied residences in 1 of which (location 7, Fig. 2) 5 members of a family of 9 were infected serially, the first 3 falling ill 2 days apart starting on 20 September, the other 2 on 30 September and 3 October respectively. Four were females, three of them children under 12. The mother and a son of 18 years died. Ironically, the husband and father, who did not become ill, was employed in unloading the 'Hecla'. All these infections may be attributed to a single mosquito, which entered the house at the earliest on 14 September, the day after work on the 'Hecla' recommenced.

A third circle drawn a further 50 m out encompasses an additional 24 occupied

houses, in 5 of which (locations 3, 6, 8, 9 and 11, Fig. 2) 11 cases of YF were diagnosed. Eight were in females. In addition, two men whose employment brought them into the circle were attacked (locations 10 and 12, Fig. 2). Of the 13, 7 died. Five mosquitoes could have accounted for all of these infections.

A final circle of 200 m radius centred on the 'Hecla' encloses an extra 73 (and a total of 99) residences that were occupied at the time. There was a single infection in only 1 of the 73 (location 2, Fig. 2), though there was a second involving a smith who lived elsewhere but whose smithy (location 5, Fig. 2) was close to the house concerned. Both infections were fatal, and both patients could have been bitten by the same mosquito.

The epidemiology of YF was totally obscure until the role of the mosquito was elucidated (Reed, 1902). In his report Dr Buchanan, having abandoned the idea of person-to-person spread, was quite positive that each patient had received their infection 'direct from the 'Hecla'', though he did not attempt to guess at the vector. His meticulous records have allowed the events to be examined so as to assess the part played by the mosquito.

The 1865 Swansea outbreak requires there to have been probably no more than ten *A. aegypti* carrying the YF virus capable of flight on board the 'Hecla' when she docked. Had there been more, the number of cases would have been larger, for there was no shortage of susceptible individuals. As the voyage lasted 44 days, it is likely that these mosquitoes represented the residue of a larger number that joined the ship in Cuba, although because some of the crew developed YF on their way home, any mosquitoes hatching on board might also have become infected. In this connection, the seaman who died shortly after arriving in Swansea fell ill on 27 August. Uninfected mosquitoes biting him at that time would have required an ambient temperature somewhat higher than is likely in order to have completed their EIP in time to play any part in the epidemic, although this is certainly not true of any that bit those on board who were ill earlier.

Once on shore, the infected mosquitoes continued to bite for as long as the temperature remained high enough, which it did from the day of the ship's arrival on 9 September until about 1 October, with a break of 3 days, 22–24 September (Fig. 1). These dates conform well with the sequence of infections, allowing for incubation periods. In this way maybe as few as 8 and perhaps no more than 10 mosquitoes could have accounted for at least 27 cases of YF, and 15 deaths.

There should be no complacency because all this happened 120 years ago. Recent cases of 'airport malaria' in Britain and elsewhere show that anopheline mosquitoes can travel by jumbo jet, and transmit infection on arrival (Warhurst, Curtis & Wright, 1984; Whitfield *et al.* 1984). Given unusually hot weather, or the interior of an over-heated airport terminal, who is to say that culicines will not follow suit?

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