Puffinosis among Manx Shearwaters on Skokholm

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(Plates 64-65)

INTRODUCTION

IN VARIOUS PAPERS, Dane, Miles and Stoker (1948-53) have described a virus disease, puffinosis, which causes epizootics (animal epidemics) among Manx Shearwaters *Procellaria* (=*Puffinus*) *puffinus* on Skomer Island, Pembrokeshire. In the past, isolated instances of the disease have been noted in the large shearwater colonies three miles away on Skokholm, but no epizootics were recorded there until 1962, 1963 and 1964.

The disease, which is only known to occur among fledglings, is characterised by blisters on both surfaces of the feet (plate 64a), conjunctivitis, spastic extensions of the legs and, in severe cases, paralysis of one side of the body which results in the individuals being unable to remain dorsal side uppermost. The symptoms vary with the epizootic. On Skomer in 1946, 1948 and 1949, and on Skokholm in 1962 and 1963, conjunctivitis was common, but there was little on Skokholm in 1964 and it was not seen at all on Skomer in 1947. Apart from

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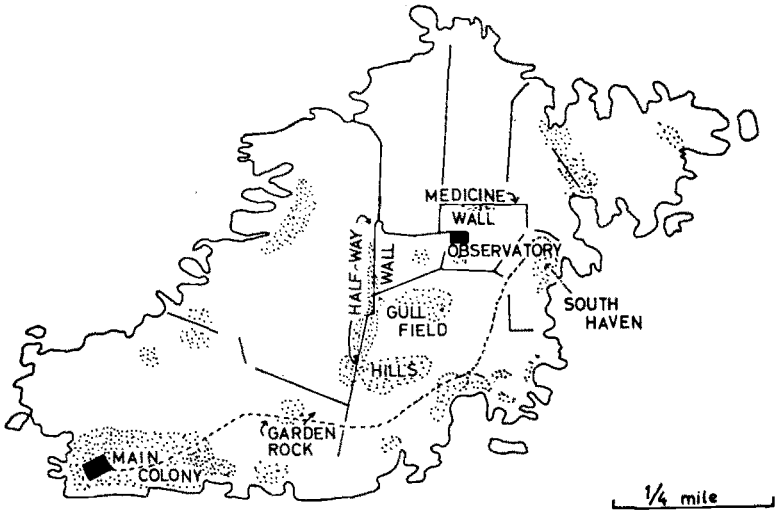

FIG. 1. Map of Skokholm, Pembrokeshire, to show the principal colonies of Manx Shearwaters *Procellaria puffinus*, the walls on the island and the names mentioned in the text. The dotted line indicates the main track

there being less paralysis, the 1964 epizootic on Skokholm was characterised by very large and extensive blisters on feet and tarsi. Paralysis does not normally affect the wings and birds which cannot stand (plate 64c) are often capable of flight if launched into the air.

This paper records the pattern of disease that was noted among Manx Shearwaters on Skokholm in the epizootics of 1962, 1963 and 1964.

GENERAL PATTERN OF THE DISEASE

(*a*) *1962*

The disease was noted in the first week of September 1962 and quickly spread through colonies at Medicine Break, Gull Field, Half-way Wall and the Hills. The names of these and other colonies are shown in fig. 1, but only the larger ones are included there as shearwaters nest in almost all areas. Small colonies are found in all the walls and in all areas of bracken *Pteridium*. All the colonies named above, and also those in which the disease occurred in 1963 and 1964, are in dense areas of bracken and near to walls or rocky outcrops.

(*b*) *1963*

The first diseased birds were found on 6th September 1963 near the Observatory and on Half-way Wall. The disease soon appeared on the Hills, Gull Field, Medicine Break and South Haven and was widespread until the end of the season.

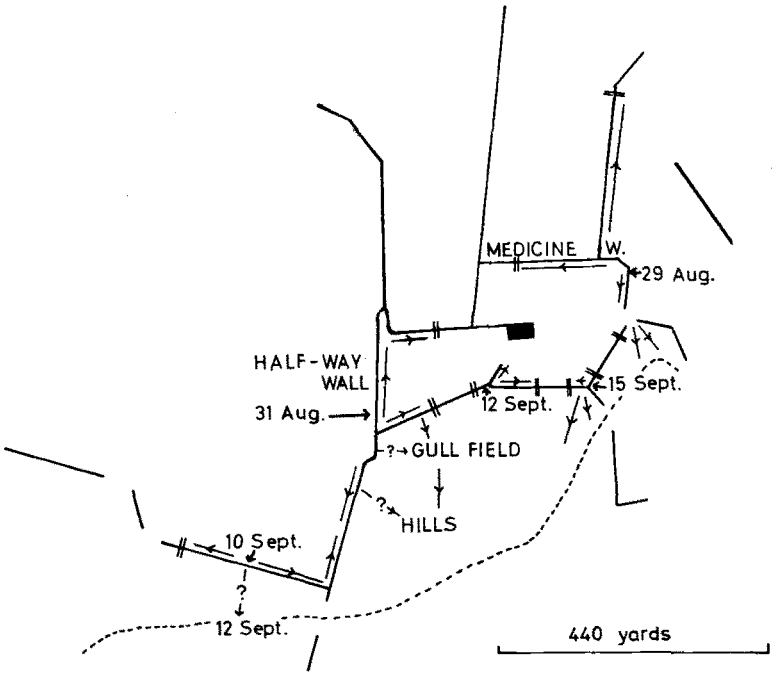

FIG. 2. Diagram of the walls on Skokholm, Pembrokeshire, to show the course of puffinosis among Manx Shearwaters *Procellaria puffinus* in 1964. Dates indicate when the disease was first recorded in each colony and arrows the probable routes of spread

Table 1. Numbers of Manx Shearwaters *Procellaria puffinus* found infected with puffinosis in the Half-way Wall colony on Skokholm, Pembrokeshire, in 1964

	Caught for first time			All including retraps			
	Number examined	Number infected	Percentage infected	Number examined	Number infected	Percentage infected	Number later dead
Before 31st August	161	0	0%	161	0	0%	14
1st-5th September	37	0	0%	38	1	2.6%	9
6th-10th September	139	24	17.3%	162	47	28.4%	23
11th-15th September	172	76	44.3%	304	168	55.2%	33
16th-20th September	27	6	22.2%	56	30	53.6%	1
21st-25th September	26	0	0%	39	10	25.6%	1
After 26th September	14	0	0%	30	0	0%	0

(c) 1964

On 29th August 1964 a young Manx Shearwater was caught at Medicine Break with severe blisters on feet and legs. Two nights later another diseased one was picked up at Half-way Wall. The disease spread rapidly amongst the shearwaters along the walls in these areas, but it was not until 10th September that it was noted elsewhere; it is possible that the later outbreaks were spontaneous and unconnected with the first one. The general details of the course of the disease in 1964 are shown in fig. 2. It was more widespread than in previous years, but included all the same areas. It was significant that it did not reach the extremely densely populated main colony.

The course of the disease was followed in the Half-way Wall colony by nightly visits, and details are summarised in table 1. It should be noted that the figures are bound to be biased by several factors: diseased individuals are slightly easier to catch than healthy ones; also puffinosis prevents the shearwaters from leaving for the sea, so that they are usually recaught, whereas non-infected ones are only infrequently seen after ringing. The peak of the outbreak was 9th to 16th September, after which the numbers infected decreased rapidly. The last one seen alive with blisters was recorded on 24th September.

WEIGHT LOSS OF AFFECTED SHEARWATERS

Seventy-nine freshly dead Manx Shearwaters with puffinosis were weighed (see fig. 3) and averaged 364 grams compared with 453 grams for 62 healthy individuals caught at other colonies from 17th to 27th September. It is known (Harris in press) that young Manx

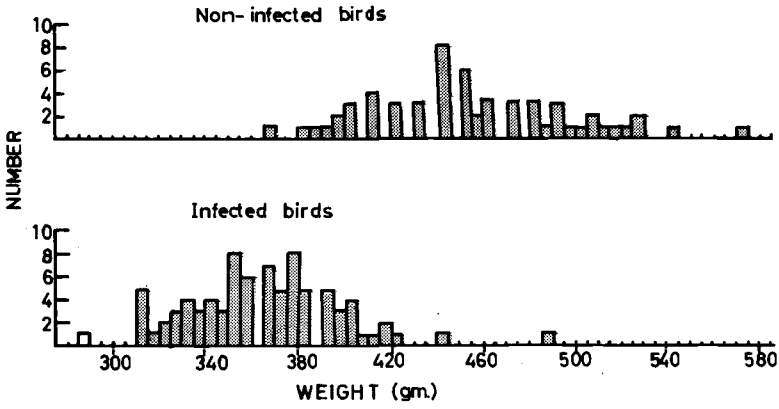

FIG. 3. Distribution of weights of Manx Shearwaters *Procellaria puffinus* on Skokholm, Pembrokeshire, in 1964: (*upper*) normal young just leaving their burrows and (*lower*) dead young infected with puffinosis

Table 2. Lengths of time between discovery and death of individual Manx Shearwaters *Procellaria puffinus* found infected with puffinosis on Skokholm, Pembrokeshire, in 1964

Length of time	Number dead	Length of time	Number dead	Length of time	Number dead
1 day	12	6 days	3	11 days	0
2 days	11	7 days	3	12 days	1
3 days	6	8 days	2	13 days	0
4 days	2	9 days	3	14 days	1
5 days	6	10 days	1	15 days	1

Shearwaters during this starvation period lose 15-20 grams a day. Young ones come out of the burrows (plate 64b) for several nights before actually leaving the colonies, in order to exercise their wings from such vantage points as rocks and walls. It seems probable that they become infected with puffinosis at this time (Dane 1948). If this is correct, it is likely that the average time between first leaving the burrows and death was 5-7 days; this is similar to previous estimates (Dane 1948; Dane, Miles and Stoker 1953). Death is not in most cases due to starvation, as the dead shearwaters often still have large fat reserves.

The observed times between marked individuals being found infected and dying are given in table 2. The average was four days, but this is minimal as it does not allow for the period between infection and when the bird was first caught.

The epizootic appeared to have died out before the last shearwaters left. However, although they showed no symptoms of the disease, these late ones were delayed in fledging and this is typical of infected birds. One weighing 440 grams on 28th September had decreased to 355 grams by 3rd October; another of 305 grams on 29th September had decreased to 255 grams by 3rd October. It seems possible that these late individuals had contracted a less virulent form of the virus.

MORBIDITY AND MORTALITY

The infection and mortality rates in 1963 and 1964 are given in table 3. These are minimal as some birds die, apparently of the disease, without showing any of the recognised symptoms; others must die in burrows or be carried away by predatory gulls *Larus spp.*, Carrion Crows *Corvus corone* and Ravens *C. corax*, all of which eat moribund shearwaters. Dane, Miles and Stoker (1953) suggested that the mortality rate of infected birds on Skomer was higher than 75%. My evidence throws no light on the true death rate, but it is certainly very high.

A few infected shearwaters succeeded in leaving Skokholm: one such ringed on 22nd September 1963 was recovered alive but weak

Table 3. Percentages of Manx Shearwaters *Procellaria puffinus* found infected with puffinosis on Skokholm, Pembrokeshire, in 1963 and 1964, and percentages later found dead

	1963			1964		
	Total sample	Percentage infected	Percentage dead	Total sample	Percentage infected	Percentage dead
Half-way Wall	305	20.7%	8.2%	576	30.5%	14.1%
Observatory	39	10.2%	5.1%	30	23.3%	23.3%
South Haven	47	25.5%	19.1%	65	16.9%	16.9%
Medicine Break				56	37.5%	19.6%
Total	391	20.2%	9.2%	727	29.6%	15.1%

at Weston-super-Mare in Somerset (100 miles east) four days later, while another ringed in September 1964 was found dead at Hayle in Cornwall (105 miles south) also four days later. It is not known if any diseased ones survive and return to the colonies to breed, but work is in progress to find out.

It is thought that approximately 1,000 chicks out of 26,500 fledged on the island in 1964 were killed by the disease. It is known that Manx Shearwaters have a very low annual mortality after returning to the island as breeders and even as non-breeders, but unfortunately the mortality in the first year of life is not known. However, it seems unlikely that these losses due to disease would have any appreciable effect on the breeding population. There are very large numbers of non-breeders present in the colonies and it is possible that they might be capable of breeding if the colonies were not already overcrowded.

MODE OF INFECTION

In 1964 seven chicks which had been weighed daily from hatching, and which had developed normally, became infected. It therefore seems unlikely that normal chicks are any less susceptible than weak or undernourished ones. The factors which appear to effect the chances of an individual's becoming infected are its hatching date and the location of the colony. The majority of the chicks in 1963 and 1964 had fledged before the disease appeared and even then the disease did not spread to the very dense colonies.

Previous workers have suggested that the disease is spread by contamination through contact with fluid from burst blisters of infected birds. This could easily happen on walls and rocks where many young congregate to exercise their wings before leaving for the sea. That would then explain why the disease is always found near walls and isolated rock-outcrops among thick vegetation and never in the very large dense colonies where the soil is very soft and the vegetation extremely short (plate 64d).

Severe epizootics of this disease have been attributed to wet summers and the associated growth of dense vegetation (Dane, Miles and Stoker 1953), but this was not the case in 1964 when the rainfall from March to August (14.6 inches) was lower than in 1963 (17.5 inches) and 1962 (15.3 inches).

Dane, Miles and Stoker (1953) tentatively suggested that puffinosis might be primarily a disease of gulls, and certainly it or a closely related virus has been recorded from gulls on scattered occasions. However, between 1958 and 1964 I handled more than 1,000 full-grown and 6,000 young gulls on Skokholm and Skomer and only twice did I see blisters which might have been due to this disease. Both these were young Lesser Black-backed Gulls *Larus fuscus* on Skokholm in 1964. It is unlikely that the disease can regularly occur with any frequency in these gull populations unless there are different symptoms. Therefore, as it is so regular on Skokholm and Skomer (see later), it seems that on these islands it must be primarily a disease of young shearwaters. However, it is worth adding that in 1963 and again in 1965 some young Oystercatchers *Haematopus ostralegus* were found dying with blistered and swollen legs and feet; these were all in areas where puffinosis occurs and it is possible that they were suffering from the disease.

As the disease occurs in the same areas every year, the source of infection must remain from season to season. A virus could not overwinter on a stony surface and, even if it did, why do the early chicks not then contract the disease? It is therefore more likely that it overwinters in some invertebrate carrier, and Dane, Miles and Stoker (1953) have shown that the virus occurs in the Trobiculid mites which abound in the area.

DISCUSSION

The first probable record of puffinosis on Skomer was in 1908 (Gurney 1913), but there were no regular observations there until 1946 when a severe epizootic occurred. Further epizootics followed yearly to 1951, when observations ceased. Since 1960, when regular observations began again, there have likewise been annual outbreaks (D. R. Saunders), always in the same areas as the earlier ones.

The first case identified on Skokholm was in 1947, but Lockley (1942) described shearwaters in bracken areas in the 1930's, which were obviously affected by the disease. There were then no more records until four 'probables' in 1954 and a single one in 1956. However, epizootics were found as soon as the disease was looked for in 1962, 1963 and 1964, and it seems likely that previous cases were overlooked. A search of the recoveries of ringed young Manx Shearwaters found dead before fledging shows that, in many earlier years, young from the Gull Field and Half-way Wall colonies were recovered 'dead but not eaten'. The death rates of birds ringed in these areas and found dead before fledging were significantly higher than those from other

parts of the island. In addition, there were then much larger numbers of Great Black-backed Gulls *Larus marinus* on Skokholm than now and it seems likely that these would have removed the majority of the moribund shearwaters before they were found by human observers. It is concluded, therefore, that puffinosis probably occurs annually both on Skokholm and Skomer.

SUMMARY

Epizootics of a virus disease, puffinosis, occurred among young Manx Shearwaters *Procellaria puffinus* on Skokholm, Pembrokeshire, in 1962, 1963 and 1964. The development of the disease was followed in 1964 when about 4% of the chicks on the island died from this infection. The disease has been recorded only in shearwater colonies among dense vegetation where there are isolated rocks or walls; it seems that only in these conditions can it be transmitted. The time between infection and death was about six days. The method of infection is discussed and it is concluded that, contrary to previous suggestions, puffinosis is primarily a disease of young Manx Shearwaters. Epizootics occur annually on Skokholm and Skomer and the virus probably overwinters in an invertebrate carrier. An appendix gives histological details of blisters caused by the virus.

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Appendix. Histological examination of Manx Shearwater feet

By G. H. Green

Feet collected from Manx Shearwaters *Procellaria puffinus* found dead on Skokholm, Pembrokeshire, during the epizootics of 1963 and 1964 were fixed in formal-saline, and wax-embedded sections stained with haematoxylin and eosin were examined. Sections were also stained in an attempt to demonstrate virus inclusion bodies by phloxin-tartrazine and Leishman-Giemsa methods.

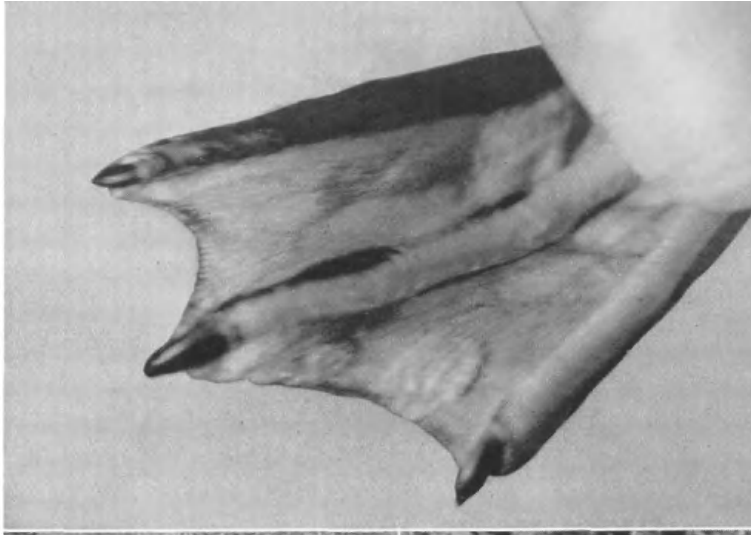
The blisters were found to form at first by the accumulation of fluid which splits the surface keratinous layer from the epidermis of the web (plate 65a). The epithelial cells beneath the blisters may show enlarged nucleoli or vacuolation of the cytoplasm in the early stages of the disease, but they are very rapidly destroyed and the whole epithelium becomes a necrotic mass infiltrated by acute inflammatory cells. The tense blister is soon broken and the stretched keratin collapses on to the remains of the necrotic epithelium. Secondary bacterial invaders may be shown in the intact blister, but are more obvious after it has been broken (plate 65b). Gram positive cocci are usually present and Stoker and Miles (1953) regularly isolated *Staphylococcus aureus* from blister fluid. Blisters may be formed on one or both sides of the web. The capillaries in the stroma of the web are often dilated (plate 65c) and the stromal connective tissues become infiltrated with inflammatory cells;

at times there is considerable haemorrhage into these tissues. In some cases, blisters are found on the toes or tarsus. Sections from these areas showed a similar appearance, but no damage to the underlying bone was observed.

Miles and Stoker (1948) and Stoker and Miles (1953) found acidophil cytoplasmic inclusion bodies in some of the cells of the epidermis. Similar bodies were observed by them in the ectodermal cells of the chorio-allantoic membrane of hens' eggs inoculated with bacteriologically sterile blister fluid. In the series of sections examined here, no inclusion bodies of any sort were found.

Sections from the foot of a young Lesser Black-backed Gull *Larus fuscus* collected on Skokholm in 1964 were similar in appearance to those from the feet of Manx Shearwaters, but showed rather less damage to the epidermis and less acute inflammation.

PLATE 64A. Foot of Manx Shearwater *Procellaria puffinus* with puffinosis. Among its symptoms, this produces blisters on both surfaces of the feet and here one that has burst and collapsed shows near the front edge of the web (pages 426-434) (*photo: G. H. Green*)



PLATES 64B and 64C. Downy shearwaters first emerge from the burrow at 60-70 days old and probably become infected then (page 429) (*photo: C. M. Perrins*). Far right, juvenile with puffinosis, drooping its wings and unable to stand; out in the open by day, birds such as this readily fall to predators (*photo: M. P. Harris*)

PLATE 64D. Part of the main shearwater colony on Skokholm. In such densely populated parts the tussocks of thrift are eroded away by the burrows and also cropped short by Rabbits. Puffinosis seemingly never reaches such areas (page 431) (*photo: M. P. Harris*)

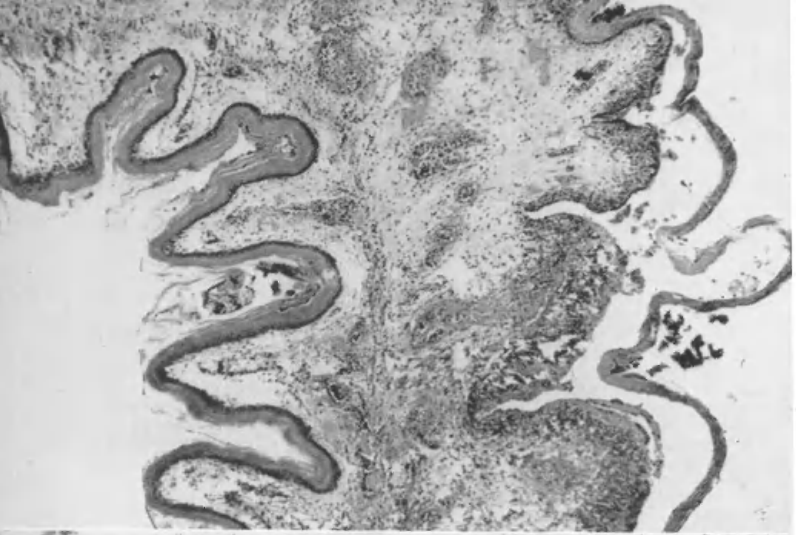


PLATE 65A. Cross-section of web on foot of Manx Shearwater *Procellaria puffinus* with puffinosis, magnification × 50. The surface layer of keratin on the right is split from the epidermis by a large blister and the end of another blister can be seen above it

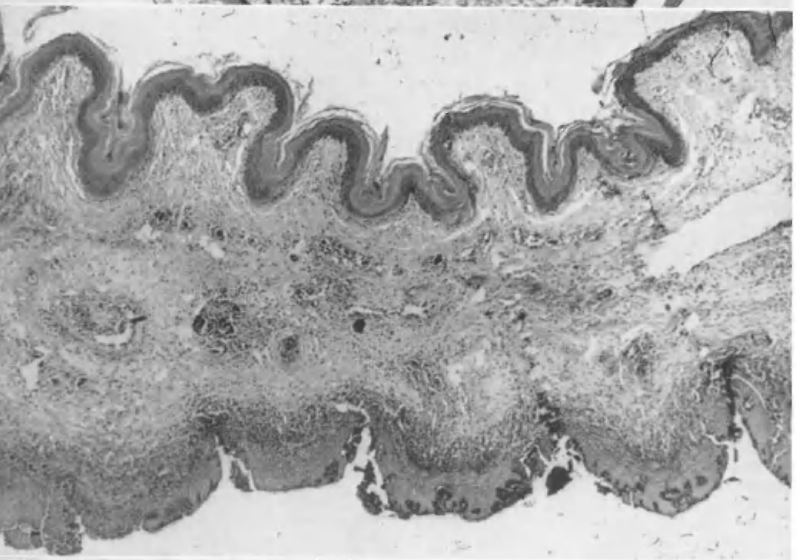


PLATE 65B. A later stage where a blister has burst on the lower surface and the layer of keratin is completely missing; the epithelium is severely damaged and colonies of bacteria can be seen as dark patches along this lower edge

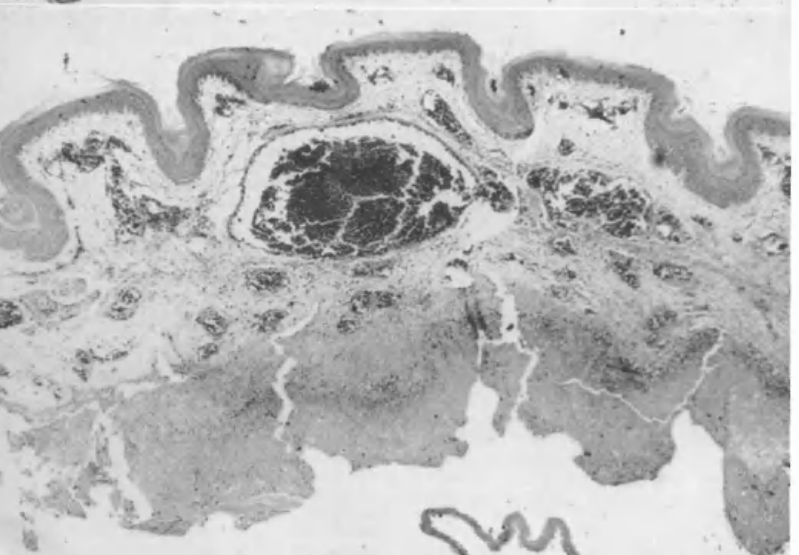


PLATE 65C. Here the epithelium on the lower surface has become replaced by a mass of necrotic material. At the same time the capilliaries are greatly dilated and show as darker patches in the middle of the section (pages 433-434) (*photos: G. Holland*)