THE PREVENTION OF YELLOW FEVER.[1]

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The prevention of yellow fever since its first importation into the United States in 1693, and especially during the latter half of the past century, has commanded, perhaps, more attention on the part of those who were concerned with matters pertaining to the public health, than the prevention of any of the other acute infections. This has not been occasioned by the fact that its total sickness and mortality have exceeded that of other acute infectious diseases, such as typhoid fever or croupous pneumonia, but because rather of the lack of knowledge of its specific agent; the consequent mystery surrounding its origin and propagation; the proximity of its source to our shores; the alarmingly rapid spread and course of this disease, when once it had obtained a foothold; and the high mortality with which its epidemics have generally been attended. Although the duration of its presence in our seaports was plainly limited by certain seasonal conditions, yet during its brief reign—July to October—its ravages were such as to completely paralyze both the social and commercial interests of a given city, and even of an entire section of our country.

The interval between 1793 and 1888 is almost one hundred years, but upon the appearance of yellow fever, we observe no difference of behavior on the part of the inhabitants of Jackson, Miss., in 1888, from that shown by the citizens of Philadelphia in 1793, except that the terror of the former was greater and their flight from their homes more precipitate than in the case of the latter. The recurrence of succeeding epidemics has, therefore, served to increase rather than to lessen the public alarm.

It would be difficult to determine with accuracy the loss of life occasioned by the ninety-five invasions of our territory by yellow fever during the past two hundred and eight years. We have endeavored to collect from the most available sources, the mortality caused by this disease, but have been unable to obtain any reliable data for the earlier epidemics. If we confine ourselves to the epidemics which have occurred since 1793, we find that there have not been less than 100,000 deaths from this cause. The greatest sufferer has been the city of New Orleans, with 41,348 deaths, followed by the city of Philadelphia

[1] The Association is under obligations to the Medical Record for the use of the cuts illustrating this paper

with 10,038 deaths. The epidemics of 1855, 1873, 1878 and 1879, claimed 7,759 victims in the city of Memphis, Tenn. From 1800 to 1876 Charleston lost 4,565 of its citizens by attacks of yellow fever. New York, during the earlier and later invasions of this disease, has had 3,454 deaths, while the epidemic of 1855 in Norfolk, Virginia, caused over 2,000 deaths. During our brief occupation of the island of Cuba, (July, 1898,—December, 1900,) with every precaution brought into exercise to ward off the disease, there have occurred amongst the officers and men of our army, 1,575 cases of yellow fever, with 231 deaths.

If we reckon the average mortality at 20 per cent., there have not been less than 500,000 cases of yellow fever in the United States during the period from 1793-1900.

Turning for a moment to other countries, we find that the great epidemic of 1800, in the province of Andalusia, Spain, caused 60,000 deaths, and that 20,000 more deaths attended the invasion of the city of Barcelona by this disease in 1821. From 1851 to 1883, the deaths from this cause in the city of Rio Janeiro were 23,338, while in the city of Havana, between the years 1853 and 1900, 35,952 deaths have been recorded from yellow fever.

We have no means of computing the damage done to the commercial interests of the United States by epidemics of yellow fever. At the Sixth Annual Meeting of this Association, held in Richmond, Virginia, in 1878, Dr. Samuel Choppin, President of the State Board of Health of Louisiana, estimated the actual cost of the epidemic of that year to the material resources of the city of New Orleans as $10,752,-500.00. Dr. Benjamin Lee, the present distinguished occupant of the presidential chair, at the Seventeenth Annual Meeting of this Association, held in Brooklyn, New York, in 1889, contributed a paper having the title: "Do the Sanitary Interests of the United States Demand the Annexation of Cuba?" From this we quote the following sentence: "A single widespread epidemic of yellow fever would cost the United States more in money, to say nothing of the grief and misery which it would entail, than the purchase money of Cuba." That this was no exaggeration witness the language of the petition which the chairman of the committee on the etiology of yellow fever, in conjunction with other prominent members of this Association, presented to the president of the United States, on November 15, 1897, and again, on November 21, 1898, in accordance with a resolution adopted at the meeting of this Association, held at Ottawa, Canada, in 1897. In addressing President McKinley, Dr. Horlbeck said: "It is hardly necessary to call your attention to the serious results of the recent epidemic of yellow fever in the states of Louisiana, Mississippi and

Alabama, but we may be permitted to mention the fact that the great epidemic of 1878 resulted in the loss of nearly 16,000 lives, and that it has been estimated that the total loss to the country resulting from this epidemic was not less than $100,000,000,00."

The importance of the study of the causative factors entering into the propagation of a disease so capable of quickly destroying the lives of its citizens and wrecking the commercial interests of the cities of the United States could hardly be over-estimated. Did time permit, we would be glad to refer to the numerous and valuable contributions made to this subject by the members of the American Public Health Association. We can only mention the establishment of the National Board of Health, and the appointment of the Havana Yellow Fever Commission of 1879 as two of the most important outcomes of the persistent efforts of this Association, following "the deeply tragical events of the summer of 1878." The exhaustive reports made by Chaillé in 1880 and by Sternberg in 1890 must always stand as monuments to the earnest spirit of investigation with which the work was pursued.

Notwithstanding the importance of the work and the efforts put forth by students in this and other countries, we believe that we are safe in saying that no results had been obtained which would enable us to successfully combat this disease when once imported into our larger centers of population, and no means found to keep it out of our ports except such as would place very heavy burdens upon commerce. This inability to control the disease grew not only out of our ignorance as to the way or ways in which yellow fever was propagated, but also out of certain false opinions which we had formed as to the mode of its spread. The doctrine of the spread of yellow fever by fomites and by filth had taken such hold on the professional mind as to completely overshadow all other views, and to direct into false channels the work of those who were engaged in the investigation of this disease. The efforts to isolate or to discover the specific agent of yellow fever, if successful, would possibly have greatly simplified the problem. In the absence of such discovery, the first step in our knowledge of how to prevent this disease could only be found, we think, along another line, viz., that of its propagation from the sick to the well. This step we endeavored to take, in connection with our colleagues, Dr. Agramonte and the late Dr. J. W. Lazear, of the United States Army, during our recent investigations into the causation and spread of yellow fever at Quemados, Cuba.

The results of our earlier work relative to the etiology and propagation of this disease we had the pleasure of presenting to this Association at its last meeting, held in Indianapolis, Indiana. You will re-

call that one of the conclusions which we then submitted was as follows: "The mosquito serves as the intermediate host for the parasite of yellow fever."[1] In the same article we briefly indicated the reasons which influenced us in pursuing this line of investigation, and it is, therefore, unnecessary to here repeat them.

Continuing our studies, especially as regards the means by which yellow fever is spread from individual to individual, and as to the manner in which houses become infected, we were able, under strict rules of isolation and quarantine, to bring about an attack of yellow fever in ten non-immune individuals (and always within the period of incubation of this disease) out of a total of thirteen (76.84%) whom we attempted to infect by means of the bites of mosquitoes—*Stegomyia Fasciata*—that had previously been fed with the blood of yellow fever patients during the first, second and third days of their attacks. These results were reported in part to the Pan-American Congress held in Havana during February of this year[2] and in part to the Association of American Physicians[3] at its last meeting held in the city of Washington.

It will be seen that we were able to establish in the most conclusive manner that the mosquito serves as the intermediate host for the parasite of yellow fever. At this same Experimental Sanitary Station we were also able to demonstrate that an attack of yellow fever cannot be induced by the most intimate and prolonged contact with the clothing and bedding of yellow fever patients, even though these articles had been previously thoroughly soiled with the excreta of such patients.

In other words. we were able to prove that the garments worn, and the bedding used, by yellow fever patients were no more concerned in propagating this disease, than the clothing and bedding of patients suffering from malarial fever are concerned in the spread of the latter malady. The doctrine of the spread of yellow fever by fomites having, at the first touch of actual experiment on human beings, burst like a bubble, we may hereafter cast it aside, with other exploded beliefs, to the very great simplification of the problem how to prevent yellow fever. Indeed, in our opinion, the time has now arrived when the latter problem may be reduced to measures which shall prevent the propagation of this disease by mosquitoes. Although the specific agent of yellow fever has not, as yet, been discovered, this must remain largely a matter of scientific interest, and does not, in the least, lessen the efforts which we, as sanitarians, are now able for the first time, to

[1] Etiology of Yellow Fever—A preliminary note, Phila. Med. Journal, Oct. 27, 1900.

[2] The Etiology of Yellow Fever—An additional note, Journal Amer. Med. Association Feb. 16, 1901.

[3] Experimental Yellow Fever, American Medicine, July, 1901.

bring into action for the prevention of the spread of this disease; since in dealing with the mosquito, we are dealing with the intermediate host which carries the specific agent from the sick to the well.

In considering, then, in a broad way, the prevention of yellow fever, the natural order would be to give our attention, first, to measures which will prevent the importation of this disease from infected places into the seaports of the United States; and secondly, to measures which will most effectually prevent the spread of this disease, provided it should gain a lodgment in one of the cities of this country.

With your permission, however, we will reverse the order of consideration above suggested, and will later refer in the briefest manner to the prevention of the importation of yellow fever into the United States from foreign ports, since this part of the subject will be presented by the health officer of the port of New York, who, from long experience, will be able to deal more intelligently than we with this part of the problem.

Since the mosquito, especially that species of *Stegomyia* which has recently been designated by Theobald as *Stegomyia Fasciata,* (formerly known to entomologists as Culex Fasciatus), has become so prominent a factor in the spread of yellow fever, it becomes necessary to consider this insect from the point of view of his identification; its habitat; its breeding places; the length of its generation; its hours of feeding; the influence of temperature upon both its propagation and stinging; the interval after contamination before the insect becomes capable of propagating the disease; the length of time during which it remains dangerous; the measures that should be used not only to protect the sick against the bites of these insects, but also to prevent the latter from infecting the healthy individual; and finally, a consideration of the several agents which may be successfully employed both to prevent the breeding of mosquitoes as well as directed towards their destruction in the adult stage.

Aside from the standpoint of scientific interest, it is certainly a matter of hygienic importance, in taking up the question of how to prevent the spread of yellow fever, when imported into the United States, that the health authorities of our several coast cities, and, indeed, of some of our inland towns, should be able to determine whether the only species of mosquito, which, up to the present time, has been shown capable of conveying yellow fever, is or is not present in these cities. If it should hereafter be proven that only species of the genus *Stegomyia* are capable of acting as intermediate hosts for the specific agent of yellow fever, as appears to have been demonstrated for the genus *Anopheles* in the spread of malaria, the presence or absence of the former genus will definitely determine whether yellow fever will or

will not spread in a given locality. The presence or absence of mosquitoes that can propagate the disease is the only intelligible explanation of what has heretofore been considered an inexplicable problem, viz., the capability of this disease to propagate itself in certain localities, while in other places it could be introduced with perfect impunity to the public health. In other words, our present knowledge of this question solves, at last, the problem of the portability or non-portability of yellow fever.

Description of Mosquito. The identification of *Stegomyia Fasciata* —Theobald—should not be difficult. This mosquito when examined closely with the naked eye and especially with a pocket lens, is a rather striking looking and handsome insect. Its most conspicuous markings are the broad semi-lunar silvery stripe which is seen on the lateral surface of the thorax, and the white stripes at the bases of the tarsal joints. These may be readily distinguished with the naked eye. The bands on the hind legs are especially well marked, and occasionally the entire fifth hind tarsal joint is seen to be of a pure silvery white. The four stripes of silvery scales which are seen on the posterior surface of the thorax serve to distinguish this species from all other mosquitoes, except *Stegomyia Signifer*—Coquillet—in which, however, as we have been informed by Mr. L. O. Howard, the curved thoracic band is very narrow and of a somewhat different shape. Examined with a hand lens, the four stripes are seen to consist of two lateral, distinct silver lines—the continuation of the semi-lunar, broad stripes—and two fine, white lines situated between these, and which require that the insect shall be held in the proper light, in order that these delicate threads may be distinctly seen. (Figs. I. and II.) The lateral surface of the thorax is also marked by several silvery dots and the abdomen by distinct white stripes. This description applies to both sexes. In the female, the palpi are short, as in the genus Culex. The proboscis is of a dark blackish brown color and is destitute of a whitish band near the middle. In the male, one of the front tarsal claws bears a tooth on the underside, while the other claw is destitute of such marking. In the female, both front tarsal claws bear a distinct tooth near the base of the underside of each.

Habitat. We have found this mosquito in all of the principal cities of Cuba, and have received specimens from a number of the smaller towns on this island. According to Howard[1] it has been found at Kingston, Jamaica, on the Isle of Pines, and at Bluefields, Nicaragua. He also reports that Theobold has received specimens of this insect from Italy, Greece, Spain, Portugal, Gibraltar and Malta. In the United States, Howard reports its presence at New Orlearns, Natchi-

1 Mosquitos, etc., by L. O. Howard N. Y, 1901.

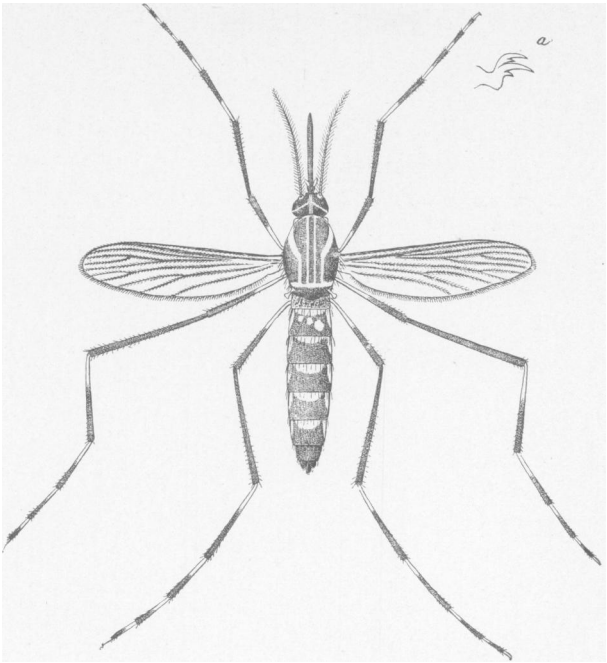

FIG. I.—Stegomyia Fasciata—Female. a.—Front Tarsal Claw.

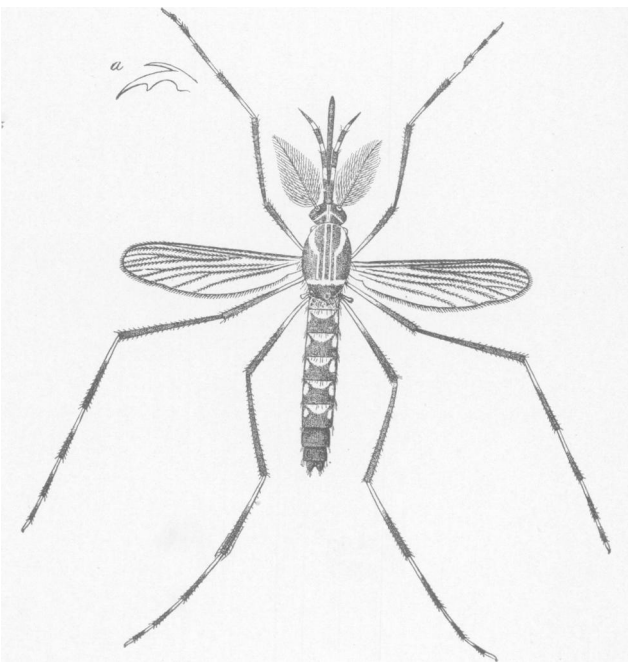

FIG. II.—Stegomyia Fasciata—Male. a.—Front Tarsal Claw.

tochez, and Napoleonville, La., in eastern Texas; Hot Springs, Arkansas; Pelham, Ga.; and from Virginia Beach, near Norfolk, Va. To this we can add Augusta, Ga., from which city we have recently received specimens of *Stegomyia Fasciata* through the courtesy of Dr. T. O. Oertel, of that city. Dr. Durham, of the English commission for the study of yellow fever, kindly showed us specimens of this insect which he had collected at Para, Brazil, and at various places along the Amazon river. It will be seen, therefore, that *Stegomyia Fasciata* has a wide distribution in the warmer countries of the globe, and especially at low altitudes. A more exact knowledge of the distribution of this mosquito in the United States is a matter of considerable practical importance.

Breeding Places. In our search for the larvæ of this insect we have found them in the following places: 1. In rain water barrels. 2. In sagging gutters containing rain water. 3. In tin cans that had been used for removing excreta and which still contained a small amount of fecal matter. 4. In cess-pools. 5. In tin cans placed about table legs to prevent the inroads of red ants. 6. In the collection of water at the base of the leaves of the *Agave Americana.* 7. In one end of a horse trough that was in daily use. It follows that *Stegomyia,* like *Culex,* will breed in any collection of still water, rain or hydrant, and that the presence of fecal matter does not seem objectionable. Indeed we have been in the habit of adding a very small quantity of the latter to our breeding jars, as it seemed to hasten the development of the larvæ. In water, however, which contains much suspended soil—muddy water—the larvæ, in our experience, do not flourish, but die off rather rapidly.

Deposition of Eggs. The insect lays her eggs during the night, and unlike *Culex,* which deposits its eggs in boatlike masses, *Stegomyia* extrudes her eggs on the surface of the water in pairs, in groups of three or more, or singly; in this respect resembling *Anopholes.* (Fig. III.) Exceptionally the eggs are deposited in a rather close-lying mass. (Fig. IV.) The whole batch is laid in one night or extending over two or three nights. The number of eggs deposited varies from about twenty to about seventy-five—rarely a larger number. Sixteen careful counts gave an average of forty-seven eggs. At the same time that the female deposits her eggs, she frequently, but not always, discharges a fluid which forms a very thin film over the surface of the water which possibly assists in floating the eggs. The latter are of a jet black color and, to the naked eye, cylindrical in shape, one end of the egg being rounded and blunt, while the other is slightly pointed, the whole resembling closely a Conchita cigar. They measure about .65 mm. in length by .17 mm. in width at the broadest part. Under a

low power, the surface of the eggs is seen to be marked by tolerably regular six-sided plates, each of which is further marked in the center by a little round elevation, which gives to the surface of the egg a decidedly roughened appearance. (Fig. V.) Under this low amplification it is also seen that while one side of the egg is somewhat convex, the other is flat or slightly concave, and that a cross-section of the egg would present the appearance of a triangle instead of that of a cylinder. This flattening of the surface of the egg does not appear to extend quite to the ends, which are round in shape. Although floating perfectly if left undisturbed, any agitation of the water, especially of a rough character, is apt to cause some or a majority of the eggs to sink. If by slight pressure the egg is pushed beneath the surface of the water, it at once sinks and does not rise again. This sinking of the eggs does not interfere with their subsequent hatching, as in our experience submerged eggs furnish about as many larvæ as those which are left floating on the surface.

The resistance of *Stegomyia's* eggs to external influences is worthy of note. Drying seems to be but little injurious to their subsequent fertility. We have found that eggs dried on filter paper and kept for periods of from ten to ninety days will promptly hatch when again submerged in water. Dried eggs brought with us from Havana in February, were easily hatched during the month of May in Washington, furnishing about 60 per cent. of the usual number of larvæ hatched from fresh eggs. Freezing does not destroy the fertility of the eggs, Although freezing with a mixture of salt and ice for thirty minutes has several times seemed to prevent subsequent hatching, on one occasion a batch of one hundred and fifty-five eggs, freshly deposited, which were frozen at a temperature of --17° C., for one hour, then thawed out at room temperature and placed in the incubator at 35° C., began to hatch on the sixth day; the majority furnishing active larvæ on the eighth day. In another observation, freshly deposited eggs, frozen at --17° C. for half an hour on two successive days, began to hatch on the third day as usual at incubator temperature. The resistance of *Stegomyia's* eggs to drying for a period of three months, would appear to demonstrate that this genus of mosquito could survive the winter in Havana, without the presence of hibernating females. Doubtless the genus is preserved in both ways. It is probable that the same could occur in our extreme southern latitudes.

Length of Generation. The impregnated female having obtained a meal of blood, proceeds to deposit her eggs, in captivity, after an interval varying in our experience from two to thirty days—as a rule, the eggs are laid within seven days—sometimes a second or third meal of blood is taken before any eggs are laid. Eggs placed under favor-

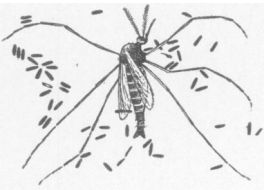

FIG. III. Stegomyia Fasciata—Batch of 52 eggs as deposited by a single female—slightly enlarged.

FIG. IV Stegomyia Fasciata—48 eggs, deposited in a close-lying mass—enlarged.

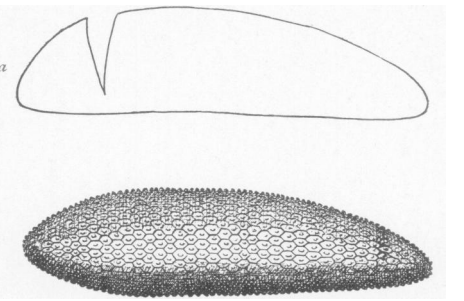

FIG. V. Stegomyia Fasciata—Newly deposited egg, X 50 diameters. a. Empty shell from which larvae has escaped.

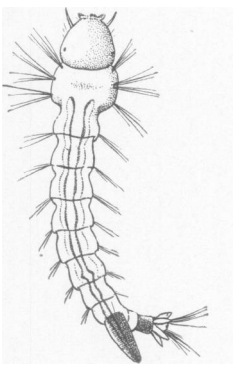

FIG. VI. Stegomyia Fasciata—Full-grown larvae—enlarged.

FIG. VII. Stegomyia Fasciata—Pupae—enlarged.

able conditions of warmth, *i. e.,* summer or incubator temperature, begin to hatch, as a rule, on the third day, the period extending to about one week. The larval stage requires seven or eight days and the pupal stage about two days. The period for the generation may be stated, therefore, as follows: Incubation, three days; larval stage, seven days; pupal, two days; total, twelve days. As the eggs begin to hatch before the expiration of the third day, we generally obtain a few mosquitoes on the eleventh day. The shortest period of development observed by us during summer weather in Cuba, was incubation, two days; larval stage, six days; pupal, thirty-six hours; making the total length of this generation, nine and one-half days. This short period, we believe to be quite exceptional. The first fully-developed insects begin to emerge on the eleventh or twelfth day, and the whole number have reached maturity by the fifteenth or eighteenth day after deposition of the eggs. The young larvæ, in emerging, rupture the shell at a point about one-fifth the length of the egg from the larger end. This cap-like end can be frequently seen turned back and still adhering to the rest of the shell. (Fig. VI.)

Influence of Temperature on Propagation. We have just seen that at summer temperatures, the time required for a complete generation of this insect is from eleven to eighteen days. We may say that at an average temperature of 75° F., or over, *Stegomyia* multiplies abundantly. Exposure to a cooler temperature, even for a short time daily, much retards the development of this mosquito. Thus a batch of fifty-one eggs kept at 35° C., but which were placed in a cool chamber at 20° C. for two hours daily during the whole process of development, although furnishing a few larvæ at the end of the third day, were not all hatched until the eleventh day. The first pupæ appeared on the fourteenth day and the first mosquito on the nineteenth day; the whole process being completed in twenty-seven days, instead of the usual fifteen to eighteen days. The loss of insects was about 50 per cent. Eggs kept at a temperature of 20° C. (68° F.) do not hatch, in our experience. Newly-hatched larvæ kept at this temperature develop very slowly and require about twenty days to reach the pupal stage. Mosquitoes developed under such conditions are feeble and but few arrive at maturity. Young larvæ kept at 10° C. (50° F.) have failed to reach the pupal stage—although some growth takes place. In one experiment more than 50 per cent. were dead at the end of two weeks, and none survived the thirty-second day. Half-grown larvæ and pupæ exposed to a temperature of 20° C., and even as low at 10° C., continue to slowly develop, but the few insects which escape drowning, have, as a rule, been of feeble strength and have refused to bite. Although the reduction of the temperature to the freezing point, or below, would not

necessarily destroy the vitality of the eggs of this genus of mosquitoes, it should be remembered that a reduction of temperature to 68° F., or below, for even a few hours of the twenty-four, will much retard the development of the generation. At a temperature less than 68° F. the eggs of this insect have ceased to hatch.

Influence of Temperature on Biting. While the non-impregnated female does not appear to bite, the impregnated female is generally ready to bite on the second or third day of her existence; they very rarely suck blood on the first day. This species of mosquito, when not deprived of its liberty, although occasionally biting during the morning hours, has, in our experience, been especially active from the hours of 4 p. m. till midnight. In captivity, the hungry impregnated female will bite at any hour of the day or night. The meal of blood appears to have been thoroughly digested on the third day, when the insects, if applied to the surface of the skin, can be again readily induced to feed. When freed in a room, the female does not appear to bite a second time till about five, or even seven days, have elapsed.

As regards the effect of temperature on the stinging of *Stegomyia Fasciata,* in our experience, the results of a number of observations show that this mosquito will bite at temperatures of 62° F. and above. At temperatures below this point, we have not, as yet, succeeded in inducing even very hungry females to suck blood. We may, therefore, say that observations thus far made appear to show that *Stegomyia Fasciata,* while not breeding at temperatures below 68° F., will still bite at a temperature as low as 62° F., but probably not at lower temperatures.

If this insect is concerned in the propagation of yellow fever, it is now quite apparent why an epidemic of this disease should fall to a low ebb in the city of New Orleans during the month of November, with a mean temperature of 61.8° F., and practically cease in December, with a mean temperature of 55.3° F. A careful study of the diagrams herewith submitted, (Figs. VIII and IX), showing the monthly mean temperatures of the cities of Havana, New Orleans and Rio Janeiro, together with the relative monthly mortality from yellow fever in these cities, will prove of interest, we think, as showing better than laboratory observations the general effect of temperature upon the breeding and biting of *Stegomyia Fasciata.* In the light of recent researches, we can now understand that while yellow fever can, and does, prevail during the entire year in Havana and Rio Janeiro—although at a comparatively low ebb during the winter months—it can not propagate itself in New Orleans from December to May.

Interval after Contamination before Mosquito becomes Dangerous. In our experimental work on human beings, we have not succeeded in inducing an attack of yellow fever by the bites of mosquitoes which

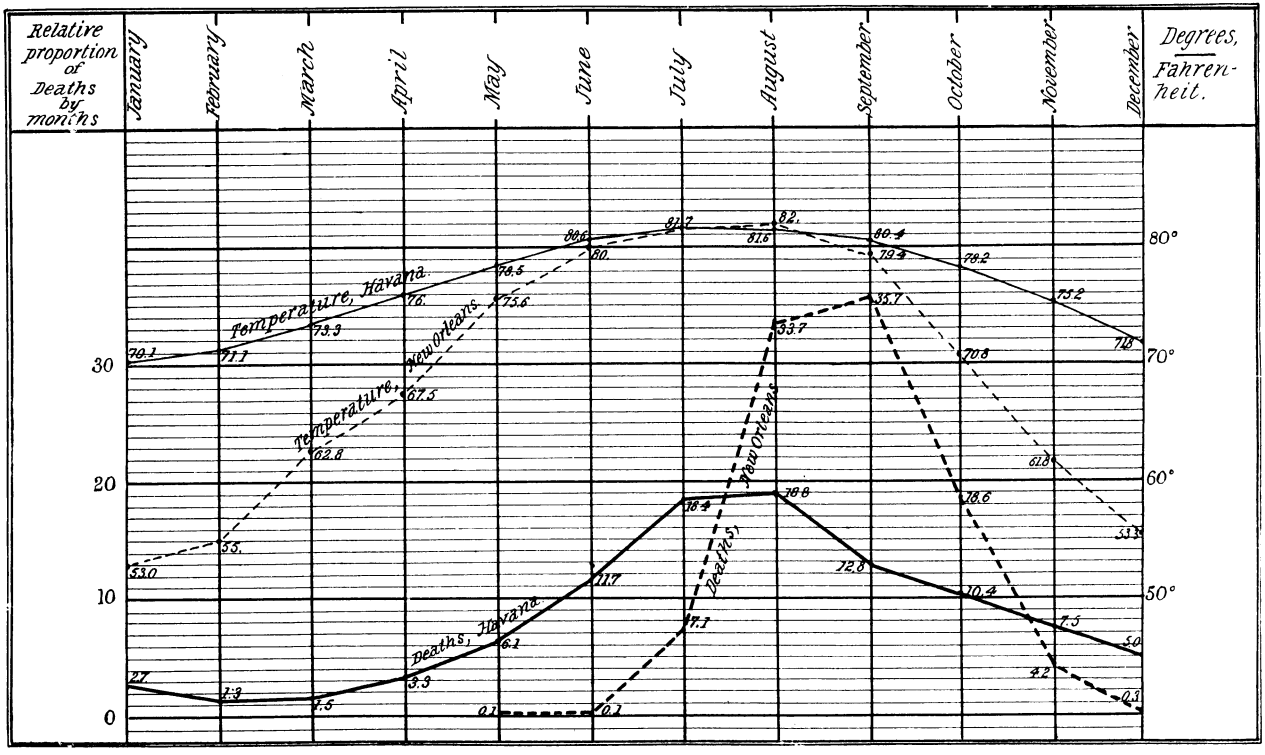

FIG. VIII. Diagram showing relative monthly percentages of deaths from yellow fever, and also mean monthly temperature for Havana and New Orleans.

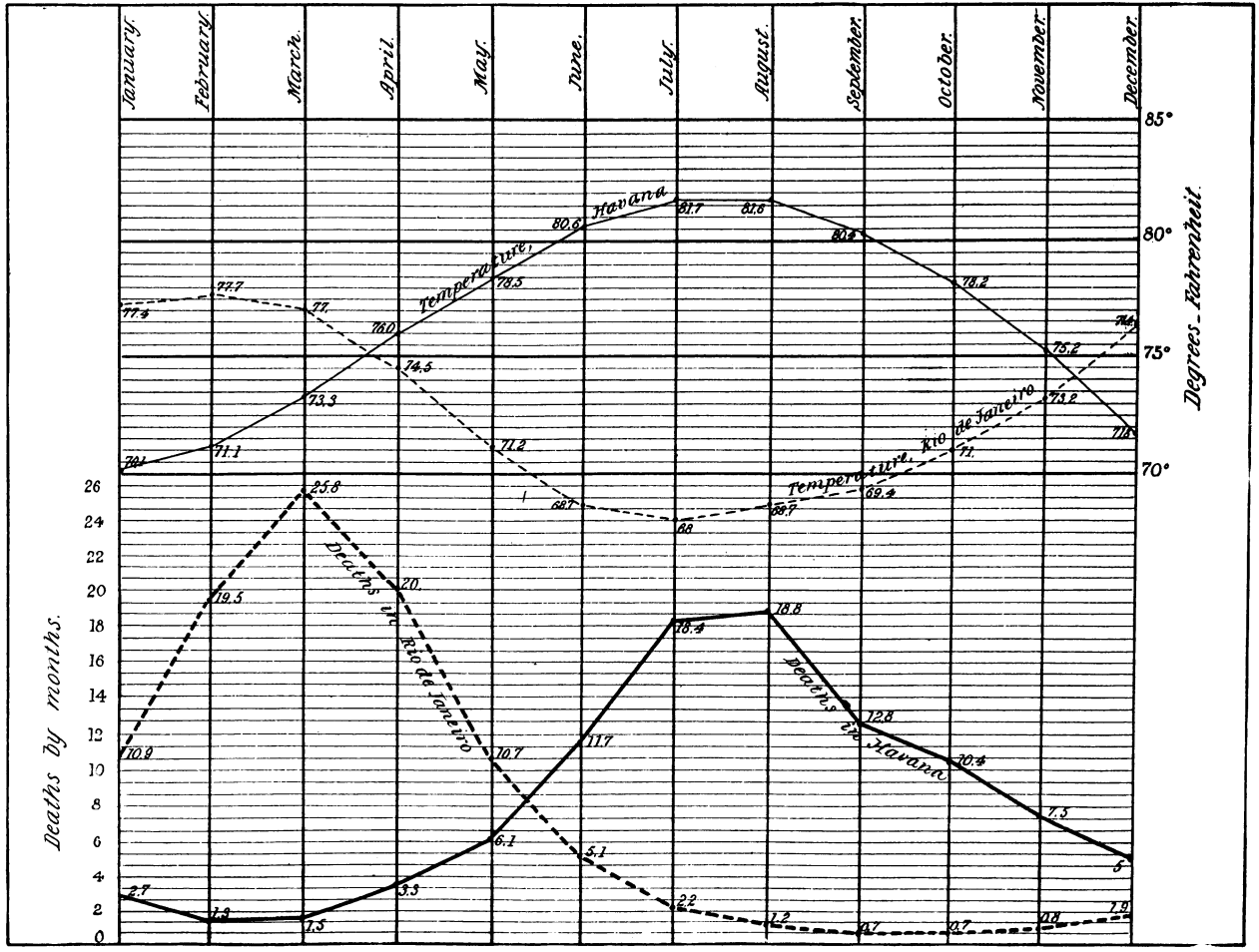

FIG. IX.—Diagram showing relative monthly mortality from yellow fever and mean monthly temperature for Havana and Rio de Janeiro. Havana, yellow fever, for the years 1890-1899. Rio de Janeiro, yellow fever, 1851-1883.

had been kept less than twelve days after contamination. The same insects which failed to convey the disease on the eleventh day, were capable of so doing on the seventeenth day after infection. This interval of about twelve days, which appears necessary for the development of the parasite within the mosquito, plus the period of incubation, agrees with the time that has been observed to elapse between the introduction of an infecting case into a locality and the occurrence of the first secondary case, viz., two to three weeks.

After the mosquito has once become dangerous, how long it remains capable of conveying the disease, although important, has not been determined. We have reported cases of yellow fever caused by the bites of insects, at intervals varying from twelve to fifty-seven days after contamination. Here the dangerous interval was forty-five days, but as one of these insects lived until the seventy-first day after biting a yellow fever patient, the dangerous interval would here be prolonged to fifty-nine days, or a little over eight weeks. In our experience, the infected insect appears to live about as long as the non-infected mosquito, so that the answer to this question would depend upon the length of life of the mosquito. This we do not know. While in captivity, the majority of mosquitoes do not survive, with the best of care, more than about five weeks, and many die within half of this time. We are ignorant as to the length of time during which they may live when under natural conditions. Certainly during summer weather this will depend largely on the opportunity of obtaining access to water by the mosquito.

Measures to Prevent the Spread of the Disease when Imported. A case of yellow fever having been imported into one of our seaport cities, we are now prepared to discuss the measures that should be taken to prevent its spread. The problem resolves itself into the simple one of excluding mosquitoes from access to the sick individual and of destroying those insects that have already become infected. We can leave out of consideration any danger from wearing apparel or baggage, which may be dismissed as harmless.

The fear that has been entertained that infected insects may be imported in boxes or trunks, we believe to be absolutely groundless, and this for the simple reason, as shown by numerous observations made by us, that mosquitoes when deprived of water, die within a few days. Even if allowed to fill themselves with blood immediately before the experiment is begun, and then deprived of water, practically all are dead by the expiration of the fifth or commencement of the sixth day. We may say that of a large number of insects tried in this way, only one female has survived until the sixth day, and then in a feeble condition. Males and females which have been living on sugar and water,

or fed two days before on blood, if deprived of water and food, begin to die after twenty-four hours, and all are dead on the fifth morning. Free access to water, therefore, is necessary for the existence of this mosquito.

Add to the deprivation of water, the chance of injury to so frail an insect packed in with articles of clothing, etc., and we see that infected mosquitoes cannot be imported alive in baggage that has been five days en route.

As the first special measure of prevention then, we should give our prompt attention to the protection of the sick individual against the bites of mosquitoes. This can best be accomplished by thorough screening of the windows and doors of the room occupied by the patient without delay and with as little disturbance as possible, so that any insects already present in the room may be prevented from escaping. As it will not be feasible to make use of any of the destructive agents against mosquitoes already within the patient's room until recovery, every precaution should be used to see that the insects do not escape in opening and closing the door. Screens at windows should not, for this reason, be movable. As it is possible that mosquitoes that have already bitten the sick individual, may have escaped into other apartments of the house, these should be closed tightly and subjected either to sulphur or formaldehyde disinfection, or to the fumes of burning pyrethrum. According to Dr. Gorgas, the efficient health officer of Havana, preference is given to pyrethrum powder, burned in the proportion of one pound to 1,000 cubic feet of air space.[1] He, however, adds: "As the pyrethrum powder, even in this large quantity, does not certainly kill all mosquitoes, the room is opened at the end of three hours, and the mosquitoes on the floor swept up and burned."

We have mentioned above, in the order of their efficiency, the agents which are most destructive to *Stegomyia*. According to our observations, an exposure for one and a half hours to sulphur fumigation, in a well-closed room, in the proportion of one pound to 1,000 cubic feet of air space, will suffice to effectually destroy all mosquitoes. Formaldehyde gas is not quite so efficient. With Trenner's formaldehyde generator, charged with formalin, 900 c. c.; glycerin, 9 c. c.; methyl alcohol, 360 c. c., which we have found quite reliable for the destruction of bacteria, an exposure of not less than three, and preferably four hours, is required in order to kill these insects in a tight room having 2,800 feet cubic capacity. Pyrethrum powder, if burned in the proportion of four ounces to 1,000 cubic feet of air space will stupefy all mosquitoes at the expiration of one hour, so that they will fall to the floor in a helpless condition. If, used, however, the precaution above recom-

[1] Medical Record, New York, Vol. 60 No. 10, September 7, 1901.

mended by Dr. Gorgas should be strictly followed; that is, the room should be opened at the end of three hours and all insects carefully swept up and burned. The practice of destroying all mosquitoes in adjoining houses, as carried out in the city of Havana, with such excellent results, we consider of the greatest importance, since only in this way can we hope to destroy infected mosquitoes and thus prevent the occurrence of secondary cases. In other words, relying upon the well-known slow progress of the spread of yellow fever, we seek to catch and destroy all mosquitoes within a given radius of the first case. If secondary cases should occur, the same hygienic measures should be rigorously enforced along the lines above indicated. Upon the completion of the case, the room occupied by the patient should be disinfected, and in a matter where so much is at stake, we believe that sulphur should be given the preference as a disinfectant. In case of death, the body should be carefully screened against mosquitoes, as *Stegomyia* will bite the dead body and might in this way acquire the parasite.

We have said nothing about the protection of non-immune individuals who enter the patient's room or house, since if the case under consideration is the infecting case, no danger is incurred. As the duration of the attack is short, generally less than ten days, the patient's room will have been disinfected and the infected mosquitoes destroyed before they have become susceptible of conveying the disease to others. We desire to emphasize the fact that the interval elapsing between the infection of this mosquito by biting a case of yellow fever and the time when it has become capable of conveying the disease, viz., about twelve days, is of the utmost importance in our efforts towards stamping out yellow fever at its very commencement, since it furnishes a non-dangerous interval during which all infected insects should be easily destroyed. It thus makes the control of yellow fever, hereafter, a simpler and more certain matter than the suppression of an outbreak of any of the other acute infectious diseases. If non-immunes entering an infected house desire protection against the bites of *Stegomyia*, this may be obtained by rubbing all exposed surfaces of the body, including the ankle surfaces, with spirits of camphor, oil of pennyroyal, or a 5 per cent. menthol ointment. The protective effect of these substances, is, however, only temporary.

What we have already said concerning the breeding places of *Stegomyia Fasciata*, should sufficiently indicate the general hygienic measures that should be taken in order to prevent the spread of yellow fever. These should consist in enforcing such measures as will effectually destroy the breeding places of this very domestic mosquito. The methods adopted by the chief sanitary officer of Havana, during the

present year, may be taken as a model by our sanitary officials. It should not be forgotten that a well-drained and well-sewered city, with a pure-water supply, has no protection against the spread of yellow fever, provided rain-water barrels and other collections of water are present, in which *Stegomyia* may breed. In one of the forts, on the outskirts of Havana, which was otherwise in an excellent sanitary condition, we found thousands of *Stegomyia Fasciata* breeding in tin cans placed about the legs of a table in an officer's kitchen. Our conceptions of yellow fever, therefore, as a "filth" disease must be abandoned, and our attention turned to yellow fever as a mosquito-borne disease. In illustration of what may be accomplished by sanitation based on the latter method of propagation, we present herewith a chart (Fig. X.) showing the actual monthly mortality from yellow fever in Havana, for the period 1880-1899, and also, for the years 1900 and 1901. Comparing the mortality from this disease for the year 1899, which was the most favorable year for yellow fever that Havana had experienced in twenty years, with the year 1901, during which sanitation, based on the demonstration that yellow fever is propagated by the mosquito, has been enforced, we find a reduction in mortality of 83.3 per cent. in favor of the present epidemic year (April 1st to August 31st); or if we compare the mortality for the epidemic year 1900, with the present year, we observe a still greater reduction in favor of the latter, viz., 411 per cent.

The sanitary regulations put into force February 15, 1901, by Dr. Gorgas, resulted in freeing Havana from yellow fever within three months, so that for a period of fifty-four days—May 7th to July 1st—no case occurred. On the latter date, the disease was brought into Havana from Santiago De las Vegas, and according to Gorgas, has been introduced into the city at least a dozen times from this and other sources. In spite of these new sources of infection, July has only furnished four cases, with one death, and August eight cases, with two deaths. If such admirable results, under new methods of sanitation, have been obtained in this hot-bed of yellow fever, we cannot believe that the intelligent and efficient boards of health of our cities will again permit this disease to assume an epidemic form in any city of the United States.

Measures Directed Against the Importation of Yellow Fever into the United States. Under the admirable system of inspection and reports, as carried out by the Marine Hospital Service, the appearance of yellow fever at any foreign port is promptly reported, for the information of the health authorities of our several Atlantic ports. We may, therefore, divide foreign ports within the so-called epidemic zone into (a) infected, and (b) non-infected ports. Heretofore no distinction has

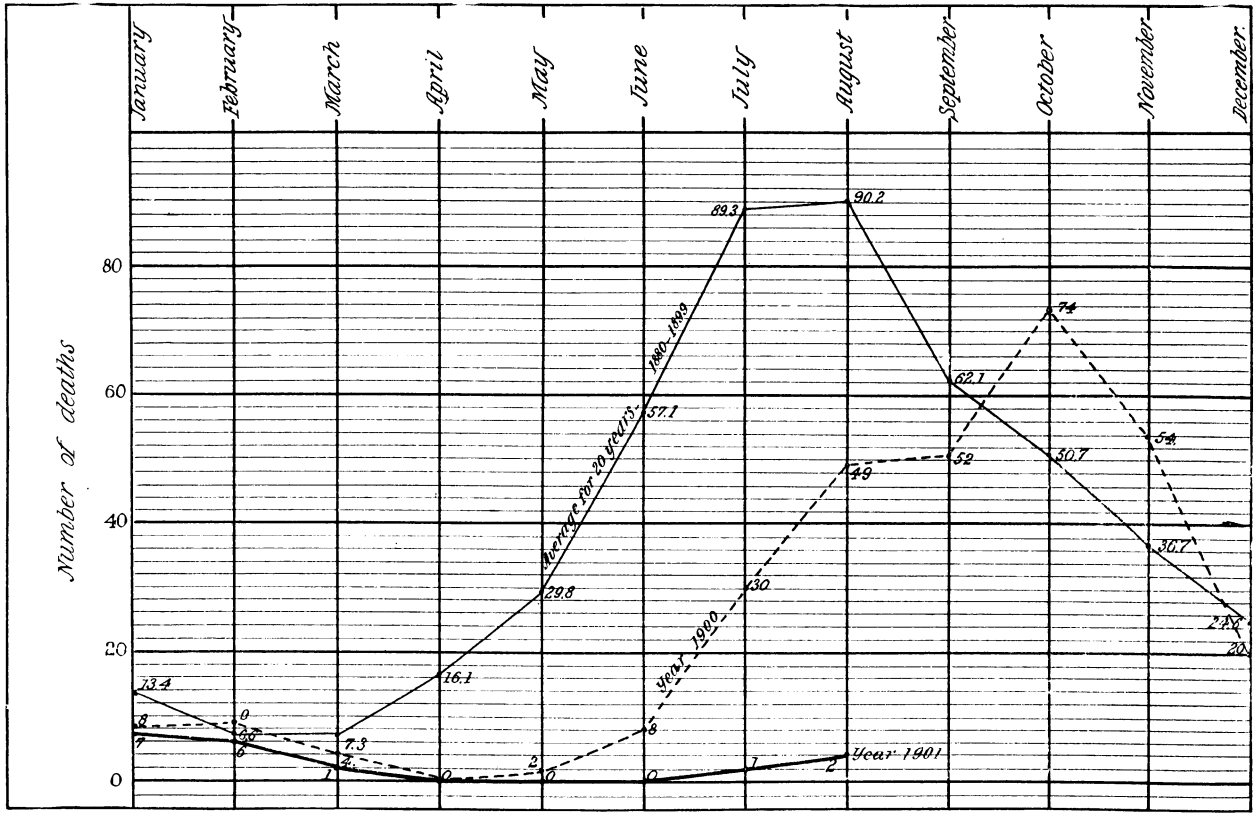

FIG. X. Diagram showing average monthly mortality from yellow fever in Havana for period 1880-1899, and from January 1st to August 31st, 1901.

been made by the health officers of our southern ports, as regards quarantine regulations, from April 1st to November 1st, between infected and non-infected places. All ports within the epidemic zone of yellow fever were considered as being infected places, and hence passengers and vessels were subjected to quarantine and to disinfection of both baggage and cargoes.

With our present knowledge of the way in which yellow fever is propagated, we believe that in the treatment of passengers, as well as of cargoes, a sharp distinction should be made, first, between infected and non-infected ports; and secondly, in the case of vessels sailing from infected ports, between those that have received their cargoes and passengers in mid-stream and those that have loaded at the wharf.

We believe that no quarantine restrictions should be placed upon either passengers or cargo from non-infected ports. In the case of a vessel loading in mid-stream at an infected port by means of lighters, we believe that she can only receive infection in one way, *i. e.*, by passengers who have been exposed to yellow fever on shore and who coming aboard may thereafter be seized with the disease. The possibility of infected mosquitoes reaching the vessel either by flight or by means of lighters may be dismissed.

Vessels, loaded under the foregoing circumstances and arriving at our ports without yellow fever developed en route, should have their non-immune passengers quarantined for five days, counting the time consumed by the voyage as part of the quarantine period, and should be allowed to discharge their cargoes without delay. If the disease has developed en route amongst crew or passengers, the sick should be promptly removed; the forecastle or staterooms as the case may be, disinfected with sulphur or formaldehyde gas, and the vessel allowed to proceed to the wharf.

On the other hand, if the vessel has received her cargo at the wharf of an infected port, there is a possibility that she may have received infection in three ways: First, either by contaminated mosquitoes that have bitten a case of yellow fever in the immediate vicinity on shore; secondly, by mosquitoes that have become infected from biting a yellow fever patient present on another vessel loading at the same, or at an adjacent wharf; or third, by some individual who has acquired the infection on shore and afterwards taken passage on the vessel.

In our opinion, however, the chances of infection of a vessel by contaminated mosquitoes coming aboard from a house or ship in close proximity are very slight; although such a possibility must be admitted, and the further possibility that recently infected mosquitoes may have sought refuge on the vessel during the night preceding her day of departure. It is also possible, that a case of mild, and hence undetected,

yellow fever may occur on board, and be the source for the infection of mosquitoes already present in the vessel.

Under these circumstances, if a sufficient number of days have not elapsed between her port of departure and port of arrival in the United States, that is, sixteen to twenty days—to demonstrate the presence of infected mosquitoes, by the occurrence of a case or cases of yellow fever en route, we know of no way of absolutely excluding the possibility of importation of the disease by such a vessel, than by the detention of all non-immune passengers for such number of days as will show their freedom from infection, and by careful disinfection of crews and passengers quarters.

If more than twenty days have elapsed during the voyage, without the occurrence of yellow fever, neither passengers nor vessel should be detained.

We have said nothing about the disinfection of the vessel's cargo for the reason that we do not consider this to be necessary. The only possible excuse for subjecting the cargo to disinfection would be the fear of the presence of infected mosquitoes in the vessel's hold, provided she had loaded at the wharf of an infected port. In this instance, if the voyage has consumed five or more days, all mosquitoes contained in the hold will have died, for, as we have already pointed out, *Stegomyia Fasciata* lives only a few days, if deprived of water. We cannot too strongly insist that the danger of importation of yellow fever into the United States lies, not in cargo or personal baggage, but in the individual sick with that disease. With our present knowledge of its propagation, personal baggage should no longer be subjected to disinfection and, with our increased ability to prevent its spread by measures easy of application, instances should be few and exceptional when a vessel coming from a yellow fever port should be delayed longer than will be necessary to remove her non-immune passengers who have not yet completed their period of five days since leaving the port of departure.

The chief duty of quarantine officers hereafter will lie in the detection of mild or very mild cases of yellow fever. In a series of twelve cases of experimental yellow fever produced by the bite of *Stegomyia Fasciata*, we have, elsewhere,[1] pointed out that four, or 33 per cent., were mild or very mild in character, and have indicated the difficulty of making a positive diagnosis in such cases.

In discussing the period of incubation of experimental yellow fever, we have shown that in 16.6 per cent. of our cases the period of incubation exceeded the usual quarantine period of five days. If we add Carter's cases to those observed by ourselves, we find that of twenty-

[1] Experimental Yellow Fever—Transactions of the Association of American Physicians. Vol. XVI, 1901.

four cases the period of incubation exceeded five days in three, or 12.5 per cent.

We can thus readily see what great danger heretofore lay in the passage through quarantine of just such mild cases, or of those having an incubation stage of more than five days.

While the exclusion of such cases is of the greatest importance, we doubt whether with our improved knowledge of how to prevent the spread of yellow fever, it would be advisable to place a greater burden upon ships' passengers by extending the quarantine period to more than five days. It appears to us rather that in view of the troublesome delays to which passengers and vessels from yellow fever ports have been subjected in the past, the time has now arrived, when standing upon more solid ground, we will be justified in seeking in every way to lessen, as much as possible, the restrictions placed by present quarantine regulations upon the ship's cargo, while we add nothing to those of the passenger.

To this end, a most important part will have been accomplished, if we can persuade the sanitary authorities of our sister Republic, Mexico, and of the Central and South American States, to join us in the adoption of more enlightened methods for the suppression of this widely-prevalent epidemic.