that they have not undergone the pressure to which the coal-beds were subjected, although, as in the case of the coal, the wood of which they were formed grew on the spot now occupied by the beds or seams. The other theory is, that the wood was washed down by the rivers from mountainous forest regions, and deposited in quiet bays of the river, where it finally decomposed, and formed the lignite of to-day.

The following are various analyses of lignite in its manufactured form, after having been dried and pressed by machinery, but without the addition of any foreign matter. Indeed, such is never added, nor is it necessary, the lignite containing within itself all the properties necessary for making it into a cleanly, cheap, and efficient combustible. The similarity of these lignite briquettes to wood as regards their heating effects, and the ashes left, will be noticed in the analyses.

*Analyses of Lignite Briquettes.*[1]

| Date. | Mine. | Moisture. | Ash. | Number of Grams Necessary to Melt One Gram of Lead. | Centigrade Heat Units per Gram. |
|---|---|---|---|---|---|
| March 16, 1887..... | Fishbach | 18.66 | 4.9 | 18.1 | 4235 |
| " 21, 1887. ... | Rottgen | 17.6 | 6.2 | 16.9 | 3954.6 |
| " 21, 1887.... | Bruhl | 13.6 | 5.4 | 18.6 | 4352.4 |
| " 21, 1887..... | Rodder Gruble | 14.6 | 5.4 | 17.9 | 4186 |

Owing to the great thickness of the bed, the working expenses are very low; and, when worked in the open, the raw material can be delivered at the works for seven pence per ton. No explosives are necessary, and as a rule the lignite is loaded direct at the working faces into the wagons of a wire-rope railway, which convey it to the mill.

In some cases, as at Honem, near Cologne, the workings are all under ground, owing to the great thickness of the layer of gravel which covers the lignite. The method pursued in these cases for working the lignite is precisely similar to the "pillar and stall" system adopted in collieries. Great chambers are cut in the lignite, and supporting pillars are left. The proportion which can be extracted by this means is about two-thirds of the mass. The surface of the ground above the workings sinks and cracks, and has to be made good, even at considerable cost; so that, whenever possible, the open system should be adopted.

The lignite rests in some cases upon a bed of pure bluish-white clay, as at Kalscheuren, and in others upon a bed of white sand. In either case the material is utilized. The clay makes beautiful white ornamental bricks and piping, while the sand finds a ready sale for a multitude of purposes. At Herzengorath the lignite rests upon this bed of sand, the sand itself being occasionally hard, and in thin beds of friable sandstone. At this mine the concession is surrounded by the collieries of the Aix-la-Chapelle basin; but as the uses for the two kinds of fuel, coal and lignite, are so different, the competition is not dreaded, the more especially as the coal cannot be burned in the stoves as at present used for burning wood; and it is as a substitute for wood, which is largely used as fuel on the Continent, that briquettes of lignite find especial favor.

The great difficulty which stood in the way of the utilization of the raw lignite consisted in the necessity for rapidly and economically driving off the excess of water it contained, and in doing this in such a manner that the quantity left could be easily controlled and regulated. Absolute dryness is by no means necessary, nor is it aimed at, and for the following reason. The lignite, like the wood of which it is composed, contains a certain amount of resinous matter; and the secret of the compressing of lignite into briquettes, and of their cohesion in that form, is this very resin which is contained in it. The pressure to which the lignite is subjected in order to form it into briquettes is enormous, and at the moment of compression it develops very considerable heat; so much so, that the hand can barely support the temperature of a newly formed briquette. Supposing for a moment that absolutely dry lignite were fed into the press, as indeed was first done: the result would be that the heat developed would be so intense as to carbonize the resin, and the briquette would have no consistency or solidity, but would crumble to pieces.

In order to obviate this, numerous series of experiments have proved that the lignite, as it enters the press, must contain eighteen per cent of water, and that this amount of water is sufficient to so modify the heat as to prevent the carbonization of the natural resin, allowing the resin to attain to a sticky state only. This, combined with the force of the blow, forms a solid briquette with a polished surface, which does not soil the hands, and which is not easily broken. A constant stream of cold water is kept in circulation around the press, so as to cool it as much as possible. The briquettes, as they leave the machine, are steaming; and the blow given to the succeeding briquette is utilized to impel those which have preceded it, straight into the railway-wagons, along channels formed of wood, but having at the bottom two iron rails to diminish the friction. By this means hand-labor is avoided for the transport, and the lignite is not touched from the time it enters the mill in the raw state until it enters the railway-wagon and is sent off to the consumer.

The briquette industry is increasing from year to year, the existing works are putting up additional presses to increase their output in accordance with their increased orders, while one or two new companies have recently started, and are in a fair way to success.

[1] The analyses were made by a qualified chemist of Cologne.

## THE CHINCH-BUG IN ILLINOIS.

THE economic entomology of Illinois has been distinguished, during the last four years, by the longest period of continuous chinch-bug devastation known in the history of that insect; but, as evidences of the disappearance of this outbreak began to accumulate last fall, it is perhaps not too soon to write its history.

Mr. S. A. Forbes, the State entomologist, states that its beginnings were apparent in 1885, when noticeable injuries to corn were reported from ten counties of southern Illinois; in 1886, thirty counties of that region were seriously damaged, Washington County (about the centre of destruction) being perhaps worst infested; in 1887 the loss was severe in thirty-eight counties of the southern district, and very noticeable in thirty-seven others of northern and western Illinois; while in 1888 small grain and corn were heavily infested throughout all the southern counties, favorable weather alone enabling the crops to withstand the injury better than the year preceding. The attack was now considerably diminished in the centre of the affected area; but farther to the east, in Clay, Richland, and Crawford Counties, it was much heavier in the beginning of the season than the preceding year, its force decreasing, however, with the disappearance of the first generation. On the extreme southern borders of the State, on the other hand, it continued with undiminished severity, the damage done in 1888 being greater than that in 1887, — greater in Pope and Pulaski Counties than ever before since their settlement. There was thus apparent a wave-like propagation outward from the centre above mentioned, the crest of the wave of increase requiring two years to pass from Washington County to the Ohio River. A similar gradual increase northward was demonstrated by a comparison of the numbers of chinch-bugs in the early spring of 1887 with those of the summer and fall, in the counties of Montgomery, Christian, and Shelby.

The recent wide-spread appearance of three destructive contagious diseases of the chinch-bug, and a consequent diminution of its numbers, make it seem at last unlikely that any extraordinary loss will follow this year in the territory which has been so long infested.

From the observations and studies reported, it appears that severe drought in the middle and latter part of the summer may diminish the number of the chinch-bug by lessening the food-supply

of the generations then breeding and hatching, and may operate also to protect the crops of the following year, at a distance from woodlands, by driving the adult chinch-bugs from the open fields, and compelling them to resort to the grassy woods for food for themselves and their young.

Severe drought in a small-grain district has so thoroughly and so early destroyed the corn-crop there, as to test practically the effect of abandoning that crop as a defence against the chinch-bug. In the case observed it was found that the injury the following season was very much less than before. As the drought took effect, however, on the field-grasses generally, and thus still further reduced the supply of insect-food, the result was not to be attributed wholly to a lack of corn.

A similar destruction of the corn by drought in midsummer, followed by a general winter-killing of wheat, has shown that a successive abandonment of these crops may greatly reduce the numbers of the chinch-bug, even where other conditions are very favorable to it; this reduction amounting, in one such case, to one-half or three-fourths of the number abroad the year preceding.

Where wheat is abundant in a district very badly infested by chinch-bugs, it is now certain that this insect may live and breed very successfully in early spring in oats, in young timothy and blue-grass meadows, and even in corn.

A thoroughgoing investigation of the relations of chinch-bug injury to the acreage of the principal farm-crops of Illinois in 1886 and 1887 shows, that, where the outbreak was but just beginning, the wheat area had evidently much to do with the number and the rate of increase of the insects; a rising gradation of injury appearing in correspondence to an enlarging area in wheat, the acreage of the other crops at the same time remaining nearly constant or slightly declining. As the severity of the attack increases, however, the oats area begins to rise with the wheat, and may presently surpass the latter as a stimulus to the multiplication of the chinch-bug, corn and grass finally showing a like tendency where it has become excessively abundant and destructive. Here, when the eggs of the winter brood are being laid freely on all the food-plants of the species, the wheat area may even decline as one passes from districts where destruction is very great to those in which it is complete. This may be due to one or more of the folfowing circumstances: (1) the wheat area may be purposely diminished by the farmers one year after another, as was certainly sometimes the case in southern Illinois in 1887, where chinch-bug injury had greatly lessened the yield and value of the crop for the season or two preceding; (2) a change of feeding-habits may arise among the insects themselves; or (3) there may be a spontaneous gradual shifting of the centre of attack, due to a natural diminution in the number of insects one year in places where they were the year before the most abundant, and an increase in places where they were then less numerous. This territorial propagation outward from a centre of first excess is accompanied by a diminution in numbers in the principal area of origin; and a similar propagation from districts where the crop most preferred and first infested (wheat) is most abundant, to adjacent districts where the leading crops are those freely fed upon, but less preferred (oats, grass, etc.), is also highly probable, but less easily demonstrated. In both cases the diminution in numbers is doubtless largely due to the direct and indirect consequences of over-crowding, — a condition which always arouses or intensifies the action of the natural checks on excessive increase.

Further comparison of the crop areas of 1886 with the injuries of 1887 shows that a very decided diminution of the corn area has had little or no effect to diminish the loss to small grain the following year.

From this we learn that the proper procedure respecting the grass and the cereal crops in the presence of a chinch-bug uprising is the prompt and early adandonment of wheat or a decided limitation of its area, to be followed presently, if the attack continues, by a diminution of the oats acreage also, and the sowing of clover, whenever practicable, instead of the grass forage-plants. We also find that these measures must be taken early or not at all; since, if too long postponed, they may easily do more harm than good.

An analysis of the published opinions of economic entomologists shows a general and rather indiscriminate dependence on the abandonment of wheat-culture as a defence against the chinch-bug; this opinion being more positive, however, among the older entomologists than among those who have studied the question recently. A similar indiscriminate but not unanimous opinion as to the advantage of the abandonment of wheat appears in the statements of two hundred agricultural correspondents of the office, eighty-seven per cent of the replies to an inquiry touching this matter being in the affirmative.

From the miscellaneous experiments reported, it appears that the worst-infested fields of small grain may be sustained under a chinch-bug attack by heavy fertilization, if the land be originally in good condition; and that, in general, the damage done will vary inversely to the fertility of the soil and the support given by fertilizers to the crop attacked. The best fertilizers for this purpose, on the wheat-lands of the central part of southern Illinois, seem to be, first, barn-yard manure; and, second, the phosphates and nitrates combined.

The kerosene emulsion, whose deadly effect on the chinch-bug was first shown by Mr. Forbes in 1882, has repeatedly proven a very valuable agent in the hands of farmers when applied in the field for the protection of corn; but it may best be used in combination with some obstruction to the passage of the chinch-bug from small grain and grass to corn, — either ditches and furrows, or belts of coal-tar along the border of the field. A mixture of coal-tar with oil or grease, ten parts to one, will last, without hardening in the sun, from five to ten times as long as the pure tar, but is too fluid to be poured directly on the ground.

Tobacco-water was found frequently fatal to chinch-bugs of all ages, but was apparently less effective than the kerosene emulsion. An emulsion of coal-tar likewise gave promise of usefulness, having the advantage in cost over the kerosene mixture, but being somewhat less convenient of application.

On the other hand, infusion of lobelia, coal-tar water, turpentine emulsion, lime-water, fresh gas-lime, arsenic, London purple, Paris green, the "Egyptian insecticide," buhach, corrosive sublimate, and steam, were applied to chinch-bugs with discouraging results.

Some starvation experiments not begun until Sept. 4 were unsatisfactory, because of the lateness of the period, and because most of the bugs from the district where the specimens used were collected, proved to be already weakened by disease. Adults and young, some just hatched, confined on a dry surface and without food, died in from one to six days. Other young, taken as they hatched, lived from twelve to twenty-four hours.

Careful studies of the contagious diseases of chinch-bugs, revealed in August and September, 1888, the presence of three distinct forms of fungous disease, two of them identical with those reported by Mr. Forbes in 1882, and the third new. All these were widely distributed through southern Illinois, with the possible exception of the region bordering the Ohio River.

Two of these diseases are produced by thread fungi (*Entomophthora* and *Botrytis*), which make a rapid external growth after the death of the insect, presently embedding the body in a snow-white mould; and the third is a bacterial disease, characterized by a minute bacillus, which has its principal seat in the cœca (not the Malpighian tubules) of the alimentary canal. Many and various culture experiments with the latter were completely successful; but infection experiments could not be made for want of specimens originally free from disease. On the other hand, culture experiments with the *Entomophthora* and *Botrytis* were tried without success.

Among various miscellaneous notes, Mr. Forbes reports the failure of an attempt to force the chinch-bug to feed on wild buckwheat (*Polygonum dumetorum*); the very early occurrence of the chinch-bug in Edwards County, Ill. (in 1823, and again in 1828); the prostration of wheat and corn as an effect of chinch-bug injury, due to failure of development of the latest circle of "brace roots;" the harmlessness and uselessness of the flea negro bug, often found associated with the chinch-bug in wheat; the place and time of deposition of the eggs for the second brood; the protective value, under certain circumstances, of the sowing of timothy with wheat in the fall; the successful defence of corn-fields by ploughing and ditching against an invasion from small grain; and an important modification of the mode of destruction by burning in the spring.