gratulated on having obtained the help of such an eminent European student as Prof. Bezzi, of Turin.

The Imperial Bureau of Entomology begins this year to supplement the Bulletin of Entomological Research by a *Review of Applied Entomology*, issued in two series—A, Agricultural, and B, Medical and Veterinary. Containing records of recent literature, with full summaries, these publications cannot fail to be valuable to students of insect life.

G. H. C.

METEOROLOGICAL REPORTS.

WE have received the meteorological observations made at the Hamburg Astronomical Observatory for 1910–12. This institution was established in the town of Hamburg in 1825, and was for many years under the able superintendence of Dr. Rümker; it is now situated at Bergedorf, 19 km. E.S.E. of its former position, and is under the superintendence of Dr. Schorr. Very complete and careful observations are made five times daily; the amount of cloud is also given for each hour between 6h. p.m. and 6h. a.m. The sunshine is recorded by Campbell-Stokes (burning) and Jordan (photographic) instruments. The average annual difference in the possible percentage for 1910–12 is 6·7 in favour of the Jordan recorder. Although the observations are not strictly comparable, we should not have expected so much difference. An interesting comparison of temperature and humidity in English and French screens is made with the readings of an Assmann's aspiration psychrometer. The hourly means of temperature in both screens are generally higher than those of the psychrometer; the greatest differences occur in daytime, especially in the French screen (open at bottom), but at the 9h. p.m. observation the reverse obtains. Humidity in the screens is generally higher than the readings of the psychrometer, especially during summer.

The report of the Sonnblick Society for the year 1912 contains the results of the meteorological observations on the summit of the Sonnblick, Salzburg (3105 metres), for twenty-five years, 1887–1911, prepared by Hofrat Dr. J. v. Hann. The mean monthly temperatures were:—January, −13·3° C. (February, −14·0°); July, 0·9°; year, −6·6°; mean of absolute extremes, 9·5°−29·7°. Mean yearly precipitation, 1715 mm., on 216·7 days. Fog was observed on 251·5 days. The mean yearly sunshine was 1496·9 hours, being 35 per cent. of the possible amount. The duration of sunshine varies greatly in different years; September, 1895, had 241 hours, August, 1896, only eighteen hours! November and January have relatively the most sunshine, May and June the least. Winter and late autumn are the brightest seasons, April to June the dullest months. Among other useful summaries contained in the report we may mention the observations at the summit of the Donnersberg, Bohemia (835 metres), for the years 1905–9. The observatory is attached to the German University at Prague, under the direction of Prof. R. Spitaler.

The report and meteorological observations at the Royal Observatory, Hong Kong, for the year 1912 have reached us; the results have been carefully prepared by Mr. T. F. Claxton, formerly director of the Mauritius Observatory. The tables include hourly values of the principal elements, five-day means, and results of magnetic observations. The mean annual air-temperature, 71·9°, was about normal; maximum, 92·5°, in September; minimum, 45·3°, in December. The rainfall, 63·9 in., was about 20·5 in. below the average. The colony was not actually visited by a typhoon, but the tracks of those and of the more important depressions which occurred in the Far East during the year are shown on two plates. A weather map and reports from about forty stations are issued daily; the forecasts drawn from these data for various districts show a very high percentage of success. A large amount of data is extracted from ships' logs; this is utilised in determining typhoon tracks, and to some extent for the eventual publication of pilot charts of the Pacific for the area 9° S. to 45° N. latitude, and 100° to 180° E. longitude, divided into two-degree squares.

HORTICULTURAL INVESTIGATIONS AT THE WOBURN EXPERIMENTAL FRUIT FARM.[1]

IN a flower, such as that of an apple-tree, there is a tubular structure in the centre, forming the female portion of the flower, and that is surrounded and overtopped by a number of rods, bearing at their extremities sacs of pollen, this constituting the male element. When a grain of pollen, either of the same or another flower, enters the central tube, or pistil, fertilisation occurs, and a seed, or pip, begins to form near the base of the pistil. As it develops, the woody substance surrounding it, which is really a portion of the stalk of the tree, gradually swells to a remarkable extent, and eventually forms the fleshy or edible portion of the fruit. We commonly call it the fruit, but it is only a metamorphosed portion of the mother-tree: the real fruit of the tree, the progeny of male and female elements, is the pip. When this is sown in the ground, it germinates, and eventually forms a new tree, which, though probably showing some resemblance to its two parents, will be a new variety, and will not bear apples of the same sort as the mother-tree. One reason which makes it all the more improbable that a pip will give rise to a tree bearing fruit like that of the mother-tree, is that in many cases the female portion of the flower cannot be fertilised except by pollen from a tree of a different variety.

As it is impossible to reproduce a fruit-tree of any given variety from seed, other methods of multiplication must be adopted, namely budding or grafting. A young tree of a similar character is taken (the stock), and in the one case a bud, or in the other case a twig (scion), from the tree to be propagated is united with the stem of the stock. All the growth arising from this bud, or buds, is similar to that of the tree from which it was taken; the stock acts as little else than a channel for conveying nourishment to the ingrafted buds; yet it does exert a certain influence on the character of the growth of scion. For apples we use two classes of stocks; the one, the crab stock, is obtained by sowing the seeds of crab-apples, and is characterised by forming a scanty number of roots, but these are stout, and have a tendency to obtain deep hold of the ground; the other, the paradise stock, is derived from a French variety of apple, and forms a much larger number of roots, but smaller, and tending to spread out near the surface of the ground. The grafted tree partakes of the character of the roots of the stock; on the paradise stock it becomes more spreading in its habit, and grows less vigorously than on the crab stock, and, whilst the former is more suitable for growing trees in the bush form, the crab stock is more suited for standard trees.

In the case of pears, the corresponding stocks are: the pear stock for standard trees, and the quince stock for bush trees.

It must be remembered, however, that the effect of the stock on the growth of a tree is a subsidiary

[1] From a discourse delivered at the Royal Institution on Friday, February 21, by Mr. Spencer U. Pickering, F.R.S.

matter; the characteristics of the growth are mainly dependent on the nature of the scion.

During removal of a tree from the nursery to the plantation many of the roots are destroyed, and nearly all of them are injured. The seat of growth of a root is situated at the extreme tip of the root, the power of multiplication being confined to a few meristematic cells which are centred there, these being protected only by some layers of outer cells, known as the root-cap, which are continually being rubbed off and reproduced from the meristematic cells, as the root forces its way through the earth. The whole root-tip is very minute, and when it is destroyed, growth becomes impossible; but there are certain cells situated at intervals along the roots which are capable of becoming modified and giving rise to new root-tips, just as there are cells in the branches capable of developing into buds if all the visible buds of a tree are destroyed.

When a tree is removed from the soil, most of the root-tips will inevitably be broken off, and the rest will become dried up by exposure to the air, so that the damage to the roots must be serious. But the well-being of a tree depends on the balance between roots and branches, both of which supply certain, but different, elements necessary for growth, and this serious damage to the roots can only be counterbalanced by damaging the branches to a corresponding extent. This is done by severely pruning the branches, cutting them back, as it is termed, to about one-third of their length. The effect of omitting this operation is often disastrous; the tree may become permanently stunted, and even, in the case of plums, which tend to bear heavily after moving, it may be fatal.

Though good horticulturists agree as to the necessity of cutting back after transplanting, they differ as to the time when this should be done. The results of our experiments on a large number of trees show that the time of cutting back makes little difference to the ultimate size of the tree, so long as it is not performed while the tree is in active growth. If it is done in the summer, however, the tree receives a serious check, from which it does not recover for at least the next seven years. Deferring the cutting back until the following winter does not give the tree any such check as regards its growth, but it affects its fruiting. Such deferred cutting back is generally followed in the second year by vigorous growth, the tree making up for the absence of growth during the first year, and it perseveres in this habit of growing in subsequent years, when it ought to be growing and fruiting as well.

Passing on to the question of the annual pruning of a tree; it is a common belief that the more you prune a tree the more it will grow. It seems fairly obvious that, even if true at all, this must be true only within certain limits; and, as applied to young, freely growing trees, it appears to be quite untrue. Various plantations of similar trees at Woburn have been systematically pruned to different extents during the seventeen years since they were first planted, and the photographs of average specimens from these plantations are sufficient to show that, as regards the general size, the trees which have never been pruned are larger than those which have been pruned moderately, and these again are larger than those which have been pruned hard. What may be noticed as to the latter is that it is a sturdier tree than that pruned moderately, the trunk and main branches having gone on swelling, while the extension of the branches was prevented by the severe pruning. On the other hand, the unpruned tree, as might naturally be expected, is somewhat straggly and not well shaped.

Another experiment will illustrate the extent to which pruning is opposed to growth. Four strictly similar twigs, 36 in. long, were selected on the same tree: one was not cut back, the others were shortened to 24, 12, and 6 in., respectively. At the end of the following season the weight of these twigs (taking the average of many series) was in the proportion of 562 : 310 : 178 : 100, and from every point of view the growth of the twigs had been greater in proportion as they had been less pruned (Fig. 1). In addition to this, it was found that there were more fruit-buds, and, therefore, a greater promise of fruit, the less the twigs were pruned; the relative proportions of fruit-buds in these cases were 314 : 238 : 165 : 100. That this promise is actually fulfilled in practice is proved by the records of the crops borne by plantations of similar trees which have for many years been pruned to different extents. In one case these plantations contained three different varieties of apples; it was found that during the first five years, and also during the second five years, the unpruned trees bore twice as much, and the hard-pruned ones little more than half as much, as the trees which had been pruned moderately. These trees were on the paradise stock; but the same was found to be the case with apples on the crab stock, for we have another plantation where 117 different varieties of apples are grown, four trees on the one stock, and four on the other; in each case one-half of them have been pruned lightly, and one-half heavily, and in both cases the crops from the latter have been less than one-half of those from the former.

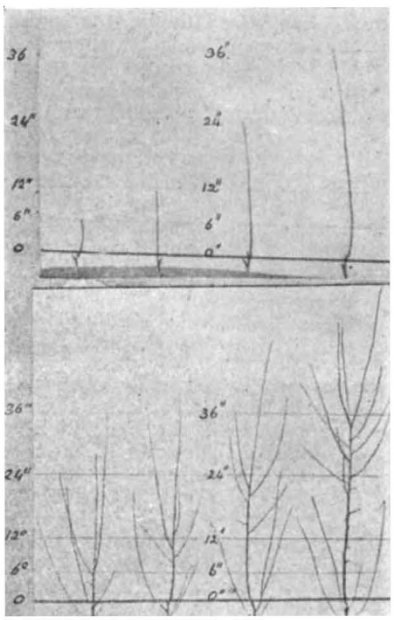

FIG. 1.—Four similar shoots cut back to different extents, showing the different growth made by them.

What has surprised us is that the heavier crops in these cases have not been accompanied by any serious diminution in the size of the individual fruits.

It is thus established as a fundamental principle, that the less pruning there is, the more will a tree grow, and the more fruit will it bear. But this does not mean that we should dispense with pruning altogether. The chief object in training a young tree is to make it sturdy and well-shaped, so that it will be capable of bearing a heavy crop when it comes to full maturity; to effect this, the extension of the branches must be checked so as to give the stem and main branches time to fill out, and occasionally a branch will have to be removed altogether, either to admit light and air into the tree, or to prevent it rubbing against other branches. To what extent this pruning should be carried, and for how long it should be continued, must depend on the habit of the tree. Instances of injury through the absence of pruning may be seen in nearly any farm orchard throughout

the country; but examples of over-pruning are almost as general, and are to be found in most private gardens, where the stunted trees throw out every year thickets of twigs, serving no other purpose than that of feeding the bonfire.

Besides the annual branch-pruning there are other operations included under the term pruning, but the only one to which I can now allude is root-pruning. In this the roots are unearthed and cut back, with the view of increasing the fruitfulness of the tree. The check which such an operation gives to the growth is very severe, and if carried to excess, will kill the tree entirely. It is evidently one which should be undertaken only in very exceptional circumstances, such as where the tree is showing rampant growth, and will neither flower nor fruit. We hear little of root-pruning except in private gardens, and we should scarcely ever hear anything of it there if a more rational system of branch-pruning were adopted. When the branches are cut away to an excessive extent, the balance between branch and root can only be restored by cutting the roots away too. But to injure the tree in one way, and to attempt to correct matters by injuring it in another way, is not a very intelligent procedure.

Passing to the problems connected with the transplanting of a tree; during this operation many of the old root-tips are torn off in lifting the tree, but others are killed by becoming dried up on exposure to the air. Some exposure is always inevitable, and in most cases several days elapse between the lifting and the planting of a tree. It is of great importance, however, that this exposure should be reduced to the narrowest limits. A number of trees were lifted at Woburn, and some of them were replanted at once, whilst others were left in a shed for four days before doing so, and it was found that the latter made only four-fifths as much growth as the former during the following season. It is on this account that planting trees in the spring should be discountenanced, as drying winds are then more prevalent; but if this drying effect is avoided, it is immaterial when the planting is carried out: similar trees planted at different times between November 28 and March 3 were found to do equally well.

Much stress is always laid by horticulturists on the importance of selecting trees with a good supply of fibrous roots, and of taking the utmost care of these roots, spreading them out, and shaking the earth lightly between them. But such precepts are based on ignorance as to the principles of root-growth. Nine-tenths of these roots have lost their tips, they are useless, and as good as dead, for they certainly will die in a very short time. Anyone can satisfy himself on this point; it is only necessary to mark a few of these roots by tying strands of silk round them, and on lifting the tree again at the end of the season it will be found that the rootlets have all, or nearly all, died, and that in their place a new system of rootlets has arisen from the thicker portions of the older roots. In fact, we have found that trees do better if the smallest of the fibrous roots are removed before planting, and also if all the roots are shortened to a certain extent. The reason of this is, not only that it is well to remove parts of the tree which are bound to die, but that the new rootlets which form will be more vigorous if they originate from the thicker portions of the old roots, where the store of material for their nourishment is greater. The practice of leaving the roots as long as possible, and carefully trimming their ends, is quite a mistaken one, for the ends of these roots, having lost the root-tip, cannot start into growth again, and it has been found that of the new rootlets which originate, only some 15 per cent. arise from the neighbourhood of the ends of the old roots, the rest originating from higher up towards the stem, or even from the stem itself.

Two other conclusions may also be drawn from what has been mentioned, namely that it can make little or no difference to the future welfare of the tree whether the ends of the old roots are trimmed, or left jagged and torn as they are when removed from the nursery, nor whether these roots are carefully spread out in the ground, instead of being huddled into the hole prepared for them; for it is the new rootlets which are to be formed, and not the old ones, on which the future life of the tree depends. Both these conclusions have been verified by actual experiment. Even when the roots were twisted and tied together in a bundle, the tree did just as well as when they were spread out in the orthodox fashion.

It is thus seen that all these practices which are supposed to be essential to the proper planting of a tree are really immaterial, and, in fact, that the violation of them within certain limits is beneficial. But the benefit was not sufficient to explain certain results which we obtained, and which puzzled us for many years. We had made a plantation in which, by way of demonstration, the trees had been planted in violation of all the accepted canons, and we expected that these trees would afford an awful lesson to the careless planter. But instead of that, they flourished rather better than their carefully planted neighbours. The results were naturally set aside as accidental, and a repetition, and subsequently many repetitions, were made; but the roughly planted trees refused to behave badly, and flourished so much more than their neighbours that they often showed two or three times more growth than these did. The principal cause of this was eventually traced to the fact that the soil round these trees had been heavily rammed at the planting, instead of being shaken over the roots and merely pressed down. When we consider that the welfare of the transplanted tree depends on its sending out new rootlets from the old roots, it is evident that anything which brings the soil into intimate contact with these roots will be beneficial, and ramming the soil down, especially if it is in a wet condition at the time, will do this more effectually than could ever be done by the gentler method of planting. These somewhat surprising results, therefore, receive a simple explanation, and it is easy to satisfy ourselves, by lifting the trees at the end of a year, that the rammed trees have actually formed more new roots than those carefully planted. Such novel methods of planting naturally excited the wrath of horticulturists, who, as a body, are inclined to carry the veneration for traditional procedure to excess, and we were careful to obtain overwhelming evidence as to the facts before publishing our results. Some seventy sets of experiments were made, in which about 2000 trees were used; the soils in which the trees were planted being of every variety, and situated in eight different counties. Naturally, the results varied, but the average of them showed that ramming might be expected to increase the growth of the tree by nearly 50 per cent., during the first or first two years, at any rate in heavy or fairly heavy soils. In a light sandy soil it naturally had no effect, for the obvious reason that, by the time the tree started into growth, any consolidation of the soil caused by the ramming would have disappeared. In one case only were the results of ramming very bad, and that was in the London clay, where the absence of aëration caused sulphuretted hydrogen to be developed. In other clay soils, no such results ensued (the Woburn farm itself is on the Oxford clay).

That trees will not flourish unless the soil in which they are growing is sufficiently aërated, is well known.

And this is the reason why a tree, when planted, should not be buried deeply in the soil; but a latitude of a good many inches in the depth at which it is planted has been found to make no difference, because the new roots, on which the life of the tree depends, form most readily at whatever depth is most suited to their development, or if they form at other depths, they soon make their way to the most favourable level.

The fact that roots flourish best at some particular level not far below the surface (the depth varying in different soils) is the explanation of some results which appeared to show the exact contrary. A number of paradise stocks were planted with their roots at various depths from 6 to 24 in. below the surface, and it was found that those which had been buried deepest, although they were the most backward at first, rapidly outstripped the others, and in two years had made twice as much growth as these had done. On lifting the trees the reason of this was apparent; in the case of those which had been planted at the ordinary depth, the root-system of the trees was the same as that which they had possessed when planted, though more developed (Fig. 2), whereas, with the buried trees, the original roots, finding themselves at an unsuitable depth, had not developed, but in their place numerous fresh roots had developed from the stem of the tree itself (Fig. 3), and these, finding ample food-material stored in the stem, had developed strongly, and formed a vigorous root-system, with the natural accompaniment of vigorous branch growth. Such results, depending as they do on the ability of the tree to send out new roots from its stem, would not be obtained if a grafted tree were buried in the same way, for roots do not easily arise from the stem of such a tree; indeed, when the experiment was made with crab-stocks instead of

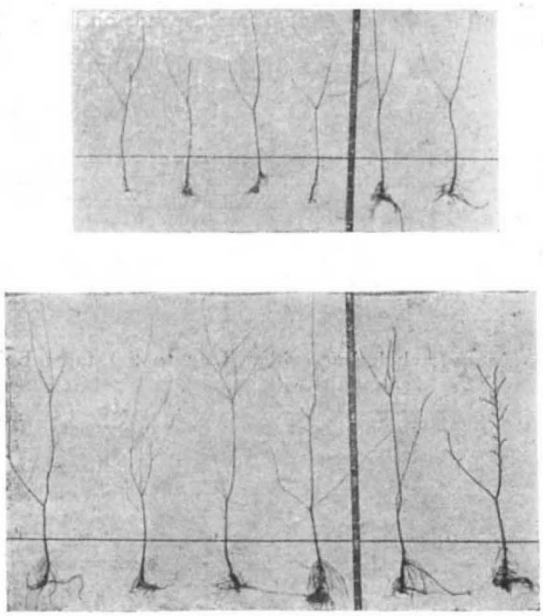

FIG. 2.—Apple stocks planted 6 inches below the surface, and lifted two years afterwards.

paradise-stocks, the results were unfavourable, for the crab-stock does not root so easily from the stem as does the paradise-stock. Thus, these experiments are the reverse of showing that an ordinary fruit-tree should be planted at a great depth.

It will be seen that all the anomalous results which have been obtained on the subject of planting are easily explained by, and are the natural consequences of, the fact that a tree when transplanted has to form a new root-system before it can begin to grow again,

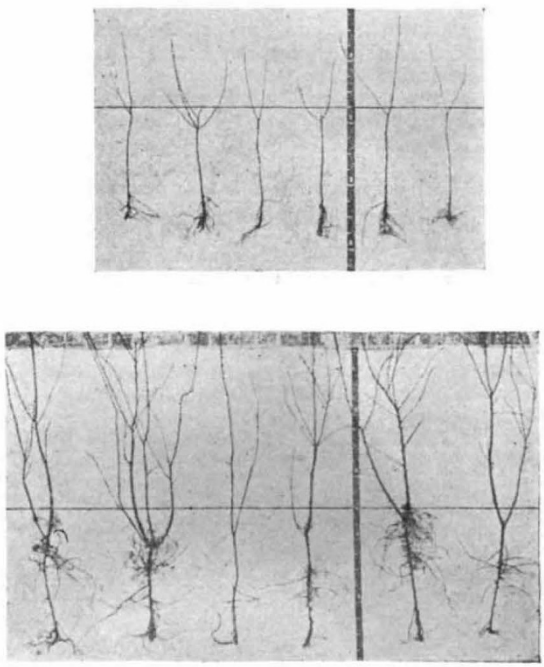

FIG. 3.—Apple stocks planted 24 inches below the surface, and lifted two years afterwards.

and if this is but kept in view, the whole subject becomes simplified, and the reason becomes evident why many of the practices supposed to be essential to the proper planting of a tree do not bear the test of actual experiment.

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1912.

FOLLOWING the custom established in 1911, the Smithsonian Institution has issued an illustrated pamphlet dealing with the scientific expeditions conducted under its direction, or in which its representatives participated. The pamphlet describes the work of about twenty different parties.

The institution was represented by two small parties in Borneo—those of Mr. H. C. Raven, who has been collecting mammals and ethnological material in Dutch East Borneo for the past two years, and Mr. Daniel D. Streeter, of Brooklyn, N.Y., who has served as a collaborator for the National Museum in the collecting of mammals, in a trip through Sarawak and Dutch Borneo.

Dr. W. L. Abbott, who financed the Dutch East Borneo Expedition under Mr. Raven, and has presented many large collections to the National Museum, has been carrying on a personal investigation in Cashmere, where he has been trapping and studying the smaller mammals of that country, specimens of which have been sent to the museum.

Through the invitation of Dr. Theodore Lyman, of Harvard University, the institution was enabled to cooperate with the Museum of Comparative Zoology in an expedition to the Altai Mountains of Siberia and Mongolia. Mr. N. Hollister represented the National