A SURVEY OF GORSE WEEVIL ACTIVITIES

IN ASHLEY FOREST

A dissertation presented in partial fulfilment
of the requirements for the degree of Bachelor
of Forestry Science

in the

University of Canterbury, Christchurch
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by

H.W. Stevenson

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SUMMARY

The gorse seed weevil (Apion ulicis) attacked 74% of seed pods sampled from six gorse infested sites in Ashley Forest, and destroyed a high percentage of seed within each pod. Statistical tests showed that the weevil did not discriminate its attack along a gorse branch. Two fungi and a 'nematode' worm were also found to attack seeds within the gorse seed pods. Combined together, the different agents destroyed a very high percentage of seeds within 94% of the sampled pods, there being no significant difference in overall attack between the six sites sampled. The amount of gorse and seed that could develop and reach the soil when the seed pod dehisced has been significantly and greatly reduced. Of the seeds that escaped attack, only 68% proved viable when a germination test was conducted.

The growth of gorse seedlings (Ulex europaeus) was compared with that of Pinus radiata. Initially gorse was slower, but it then increased height growth substantially, overtopping the pine seedlings within one hundred and thirty days of soil emergence.

INTRODUCTION

The initial aim of this dissertation when it was planned in late 1972, was to determine the amount of gorse seed in the soil under heavy infestations of gorse (Ulex europaeus) in Ashley State forest. This figure was then to be related in later work, to the success of various silvicultural land preparation methods, such as burning, discing and spraying, which are aimed at overcoming gorse infestation. According to Ferens (1957), samples from many different areas indicate 10 to 20 million seeds/ ha in the surface 3 cms of soil. However, I noticed a low number of seeds in my preliminary soil samples so looked at the seed pods to determine whether in fact, seeds were being produced. Every pod I opened at that stage had been attacked by the introduced gorse weevil (Apion ulicis), so emphasis was shifted to study the effectiveness of the gorse weevil in destroying seeds on the gorse plant.

The gorse infestation problem is of major concern to the New Zealand Forest Service as it is costly and time consuming to eradicate and present methods seem to give very variable results. The difficulty is due in part to the longevity of the seed in the soil. Though it is not definitely established, various authors suggest that the seed can remain viable in the ground for anything from 25 to 50 years.

A full technical description of the gorse weevil can be found in Miller's (1970) book. In summary, the gorse weevil is a small insect approximately two millimetres in

Photograph 1: Gorse weevil (Apion ulicis)

length with colour ranging from silvery grey to black. As can be seen in Photograph 1, the insect has large prominent eyes and a long slender snout which is usually directed beneath the body. The pin which is also visible in Photograph 1 is in fact a "micropin" which gives a good indication of scale. The photograph was taken microscopically. The plump, whitish, legless larvae attains a length of about two millimetres, while the pupa is much the same colour and length as the mature larva.

The liberation, establishment and life cycle in New Zealand are also described by Miller (1970). The first liberations occurred on 25th February 1931 at the Cawthron Institute in Nelson and on the 27th of that month at Alexandra Central Otago. General distribution throughout New Zealand commenced in 1934 and was continued until 1947 by which time two hundred thousand had been sent to three hundred and forty localities (Miller, 1947).

Establishment is now country wide; the insect has spread freely, mountain ranges being no barrier. The highest pod infestation so far recorded is 98.67% at Alexandra and 80% is common in Waimea county; but no comprehensive survey has yet been made. Recent records by Moss (1960) reveal that from 20-40% of the summer seeds were destroyed in areas near Wanganui, and 41% in the Manawatu.

No proper field study of the bionomics of A. ulicis in New Zealand has been undertaken; the only records available are of sporadic yearly observations made from the time of liberation in 1931 until the close of 1940, and the following account has been constructed there from.

"Weevils occur on gorse throughout the year; though usually dormant during winter, there is no true hibernation, the insects responding to favourable winter conditions (as does gorse), and even reproducing in that season. As was found with some consignments of imported weevils from Britain, an autumn generation is produced. As far as is known, the major reproduction activities take place from early spring until late summer when suitable pods are available; pods of the autumn flowering dehisce in late autumn (perhaps also in winter), and in spring (August and September) releasing the autumn and any winter generations of weevils; pods from the spring and summer flowering dehisce from October until the following February and March, during which period the spring and summer generations are released.

When young pods become available in spring, the female weevil inserts a cluster of eggs into the seed chamber through a hole made with her snout in the tender wall of a pod. In about three weeks, the whitish larvae hatch, devour the seeds, and pupate in gelatinous cocoons until mature. The weevils emerge from pupae when the pods are blackened and ripe, but cannot eat their way out, having to await the bursting of the pods, when they are ejected. The complete life cycle takes from eight to ten weeks." Miller (1970).

Davies (1928) stated that the weevils were found not only to be highly specific to gorse, but in fact the life history is so tied in with the plant growth phases that it would be difficult for it to breed on another plant.

METHOD

There are two dominant flowering periods during a year. According to Miller (1970), a minor one occurs from February (in early autumn) until May (in early winter), and a major one from July (late winter) until December (mid summer), the periods of fruiting and seeding being about two months after the beginning and ending of the flowering periods. I was fortunate to be working in Ashley Forest at the end of the major seed producing period, and so there was an abundance of seed pods to sample.

I selected six sites within the forest where gorse was the dominant ground cover, and sampled unopened pods from each site. It was not practical to sample on an areal basis, so instead I used a "number of pods sampled" basis. The sampling sites are marked on the map in Appendix C.

At the first site I sampled I divided each branch into the top 35.6 cms and below. This was an attempt to find if there was any difference in weevil attack along the branch. The remaining five sites were sampled by walking through the area, picking pods from positions all over the bushes in a random fashion.

For each pod, I measured its dimensions, (length and breadth), counted the number of weevils and noted any oddities such as attack by a different agent. The seeds that remained untouched and apparently viable were collected and a germination test was run on them. The seeds were soaked in concentrated sulphuric acid for fifteen minutes in an endeavour to degrade the seed coat; after a thorough washing they were then placed on absorbent towels with access to a water supply and kept in an incubator initially at 25°C.

Some of the seeds that germinated were placed in potted soil and grown in a glass house. The growth rate of gorse and <u>Pinus radiata</u> were compared for the same growing conditions.

Photograph 2: An opened gorse seed pod showing the honey-comb structures in which the gorse weevil pupates.

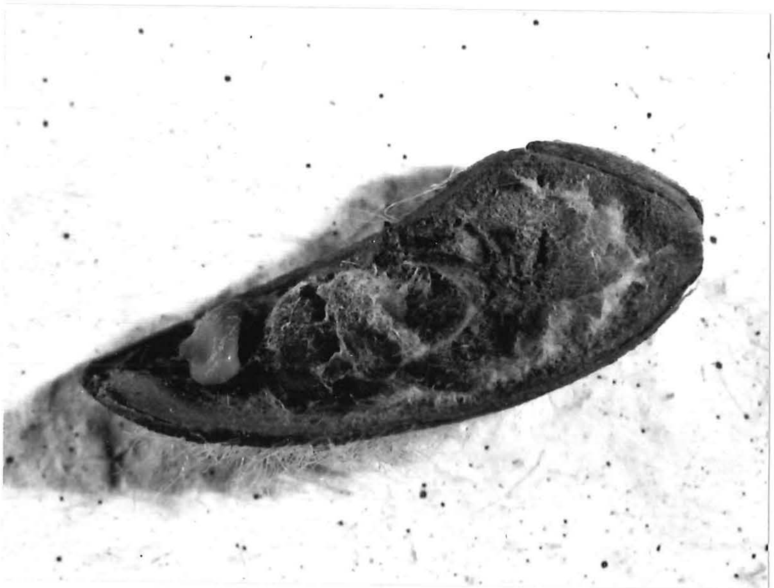
RESULTS

The gorse weevil was responsible for attacking 74% of one thousand three hundred and sixtyone sampled seed pods. Generally every seed within a pod was attacked, and in most cases there were no visible remains of the original seeds. However, occasionally one or two seeds within a pod escaped attack and thus remained theoretically viable. These seeds were collected along with those from unattacked pods and a germination test run.

In 6.6% of the attacked pods, all the weevils had died in an immature state; this could probably be ascribed to overcrowding as there were a large number of insects present in each pod. However, even though dead, the weevils had destroyed the seeds. The largest number of live weevils found in one pod was twenty four, this is higher than that found by Miller (1970) which was nineteen. The average number of weevils per attacked pod was 5.1 which fell between Miller's figure of 6.0 and Davie's (1928) of 4.6.

As can be seen in Photograph 2, the insects pupate in a honeycomb-type structure. Generally this is one cell deep over most of the pod but in the deepest section there were generally two cells, one on top of the other. From general observations it would seem that the action of the pod dehiscing under dry hot conditions would breakdown the walls of the cells thus releasing the weevils, rather than the weevils breaking down the cells themselves. Many times, I only removed a portion of the top half of the pod and only the

Photograph 3: Half a gorse seed pod showing two seeds attacked by fungi.



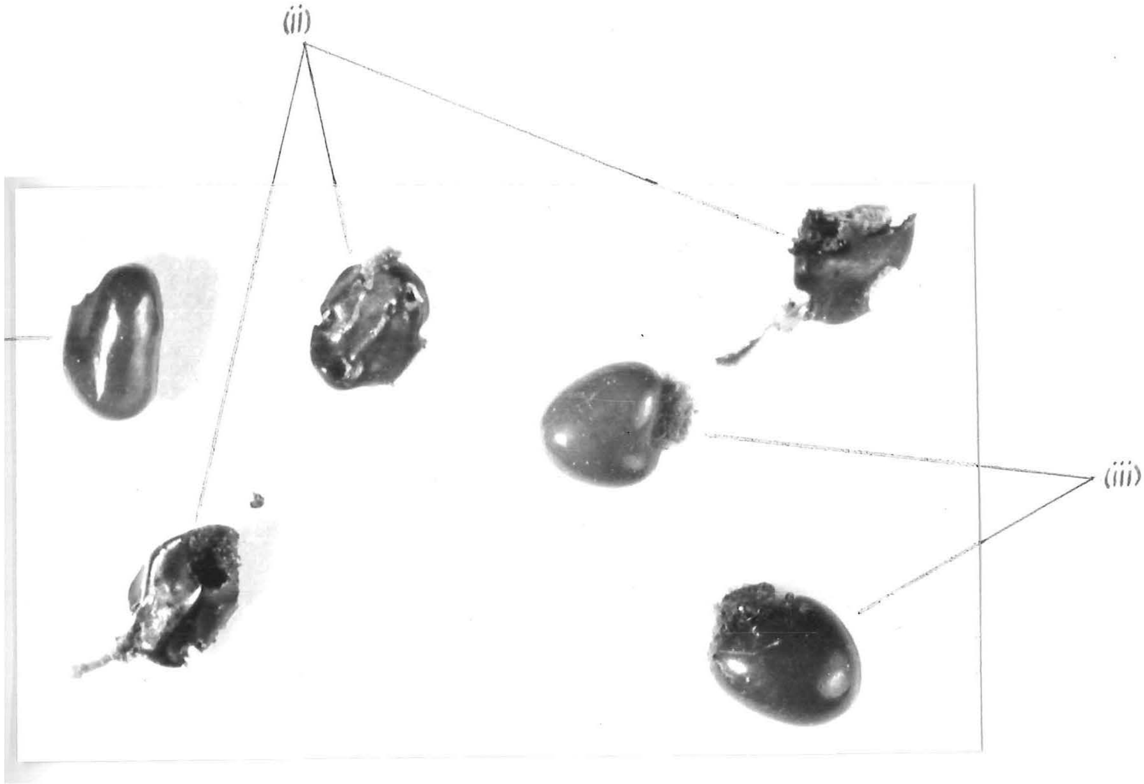
Photograph 4: Half a gorse seed pod showing the amount of debris in a pod attacked by fungi.

weevils in that vicinity escaped, the others escaped only when the whole side covering of the pod was removed.

Apion ulicis was not the only other agent attacking the gorse seeds. Several types of fungi and a "nematode worm" attacked 19% of the sampled pods, so in fact 93% of all pods were attacked. Because of lack of suitable facilities over the period the pods were opened, no attempt was made to identify the other agents specifically. A normal unattacked seed pod has a clean shiny interior with no debris of any kind, and the seeds have hard glossy coats with a bright yellow funiculus. However, as can be seen from the two Photographs 3 and 4, attacked pods are filled with debris, and the seeds are barely recognisable being covered with mycelia when attacked by the fungi, which varied in colour from light to dark brown. When the seeds were uncovered, they were found to be shrivelled and a dullish brown, and they generally did not germinate when tested.

Another type of fungus was also found and can be seen in Photograph 5, only the yellow funiculus was attacked by a pink fungus. The seeds were loose in the pod. Perhaps the fungus could have spread further if the pod remained unopened. Also visible in this photograph are three seeds with entry-exit holes in them, produced by a type of nematode worm about ten millimetres long with a light brown segmented body and black head. Though only three worms were found, their damage was visible in a number of pods. These seeds are contrasted with a viable seed.

All three kinds of attack must have resulted from forced entry into the pod by some external agent. It is known how



Photograph 5: One normal gorse seed (i), three seeds showing damage by 'nematode' worms (ii), and two seeds showing fungi attacked in the region of the funiculus (iii).

RESULTS. TABLE 1. SUMMARY OF SURVEY DATA

Sampling Site	Coppin Road 0-35.6 cms	Coppin Road 35.6-66 cms	Coppin Road Overall	Kowai Road	Paringa Hills	CPT 95	CPT 92	HQ	Overall
No.Pods.sampled	247	188	435	256	159	251	165	95	1361
No.Pods.attacked	216	161	377	179	101	200	111	33	1001
% Pods attacked by weevil	87.4	85.6	86.7	69.9	63.5	79.7	67.3	34.7	73.6
No.weevils/attacked pod	4.7	6.0	5.0	4.2	5.1	6.4	5.2	3.9	5.1
No.Pods attacked By other agents	23	25	48	39	47	40	38	47	259
% Pods attacked By other agents	9.3	13.3	11.0	15.2	29.6	15.9	23.0	49.5	19.0
Total % attacked	96.8	98.9	98.3	85.2	93.1	95.6	90.3	84.2	92.6
Total No. weevils	1020	974	1994	755	511	1290	579	130	5085
No.Viable(?) seeds	40	5	45	174	20	27	23	38	326
% Pods with viable (?) seeds	12.0	4.2	9.2	16.8	7.6	10.8	6.7	14.7	8.2
Av. Dimension of pods cms	15.6x 5.0	14.8x 4.7	15.5x 5.0	15.5x 5.2	14.9x 4.9	15.9x 5.2	14.5x 5.0	15.3x 5.2	15.4x 5.1
Index of Pod size	78.0	69.6	77.5	80.6	73.0	82.7	72.5	79.6	78.5

the weevil starts its life cycle within the pod, the worm can probably enter the pod of its own accord, but how the fungi enter is not definitely known. One explanation could be pod puncture by a sterile female weevil, then entry by the fungi through the resulting hole. It is certainly not present in the healthy developing pod, the inside of an immature pod would be expected to be sterile. The pods may have been degenerate and then attacked by the fungi at an early stage, through the prescence of recognisable seeds suggests a later time of attack or else the fungi do not stop the development of the seeds, and they progress simultaneously.

The survey data for this dissertation are presented in Table 1 and the results of statistical tests on these data are presented in Appendix A.

Chi-square tests were conducted on the data. With the null hypothesis that "attack did not depend on sampling site", differences were looked for in weevil attack, 'other agents' attack and attack by all agents.

For pods attacked by the weevil, Coppin Road and HQ differed significantly from the expected at the 5% level. Coppin Road had a higher level of attack than expected while HQ had a lower level. I cannot detect, from my observations in the field and the results of my experiment, a reason why Coppin Road should have a significantly higher attack level be weevils. It is interesting to note however, that Coppin Road also has the highest sample number and HQ the lowest sample number. Whether this has any bearing on the results is hard to tell.

When the test on attack by 'other agents' is considered

RESULTS.

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Sampling Site	Coppin Road 0-35.6 cms	Coppin Road 35.6-66 cms	Coppin Road Overall	Kowai Road	Paringa Hills	CPT 95	CPT 92	HQ	Overall
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Index of Pod size	78.0	69.6	77.5	80.6	73.0	82.7	72.5	79.6	78.5

the only significant difference occurs for the HQ sampling site where the attack is significantly higher at the 5% level. Why there is this difference in weevil and 'other agents' attack at this site is difficult to explain, but it could be hypothesised to be due to a basic difference in the pods at the time of weevil attack, for instance sterility or some degeneration of the pod which the weevil can detect and discriminate against. However, 'other agents also attack fertilised seed pods as seen previously so at the HQ sampling site, some complicating factor which was not discovered in this experiment may be the causal reason.

Attack by all agents showed no significant differences between sites, so its seems that the differences in attack of the HQ site finally cancel themselves out to give a total percentage attack of no significant difference from the remaining sites.

A chi-square test based on the null hypothesis that "the ratio of number of weevils to number of sampled pods did not depend on site" showed that HQ did have a significantly smaller number of weevils at the 1% level and is thus consistent with the previous tests.

A chi-square test based on the null hypothesis that "the number of pods with potentially viable seeds did not depend on the site" showed that there was no difference between sites.

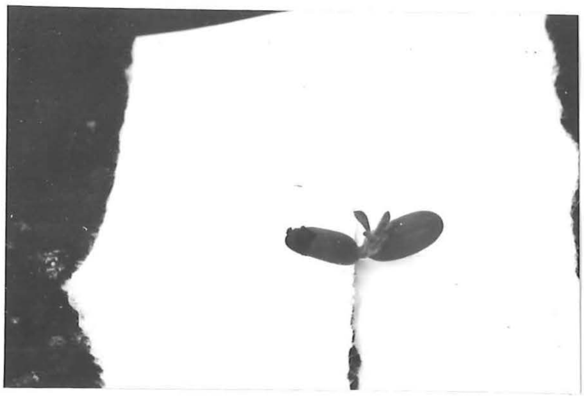
A final chi-square test based on the null hypothesis "that weevil attack did not depend on position of the pod on a gorse branch" did not reveal any significant differences so it would seem that the gorse weevil does not discriminate its attack along the branch. However, study of the results in Table 1 shows that more of the terminal pods (0-35.6 cms in the Table) have potentially viable seed within them even though weevil attack is not significantly different. If we consider the number of weevils per attacked pod, we see that the terminal pods have lighter individual attack so it would seem that this ratio is very significant as far as viable seeds is concerned, the more weevils per pod, the more likely all seeds will be destroyed.

Germination Test. Of the three hundred and twentysix seeds that were tested, 68% of them did germinate. Initial germination was slow, sixteen seeds germinated in the first fortnight at 25°C. Some of the seeds than had part of their seed coat removed by razor blade. In the next fortnight, twentyfour seeds germinated, most of them having been treated by razor blade. The incubator was then turned off and obtained a steady temperature of 18°C with a high humidity. In the next three weeks one hundred and forty seeds germinated. The high humidity was maintained and the seeds kept germinating rapidly. When the humidity was allowed to decrease, germination almost ceased. It would seem therefore that once the seed coat has been degraded sufficiently, a high humidity is more important than temperature for germination.

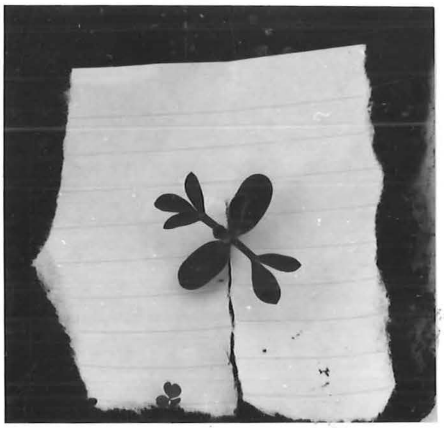
Growth of Gorse. As can be seen from the graph comparing the growth of Pinus radiata and Ulex europaeus seedlings in Appendix B, the growth of P. radiata is initially much faster than U. europaeus, which after a slow start grew very rapidly and developed from small bushy-type plant (Photographs 8 and 9) to a tall spindly one (Photograph 10).

The slow initial growth of gorse could quite probably be caused by development of a good fibrous rooting systems including nodules, at the expense of shoot growth. As conducted, this last experiment was not very satisfactory for obtaining quantitative results, but definite trends have been obtained in growth patterns as can be seen from the photographs which range from six days after soil emergence in Photograph 6 to one hundred and fiftyone in Photograph 10 to 12. Green spines characteristic of the mature adult have just formed but at this stage are not firm and therefore not prickly. However if the seedlings had been exposed to the elements, particularly frost during its development, stout spines may form at an earlier stage. It would seem that if stock are to be used in a land preparation schedule involving gorse, they have three months at minimum to eat or trample the gorse seedling while it is still in a relatively vulnerable state. Gorse was originally introduced into New Zealand not only as a protective fence but also as stock fodder. Therefore the use of stock in site preparation on gorse infested areas in New Zealand forests should be very helpful and is a method which could be evaluated both for effectiveness and cost compared with present methods.

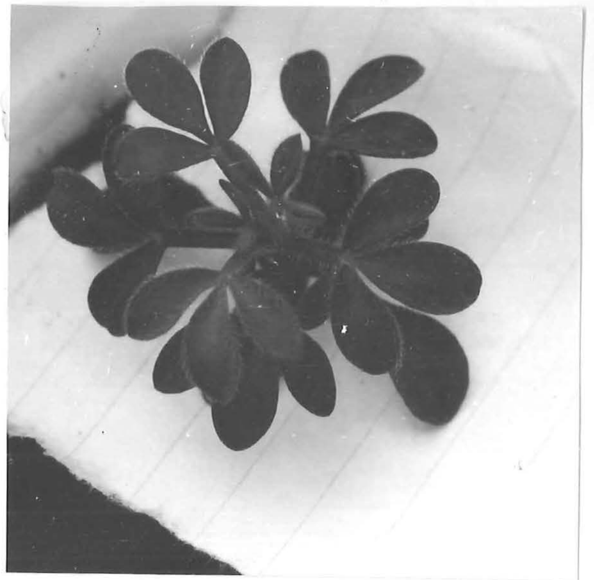
Doubts about the available rooting space in the pots, the number of gorse seedlings growing, and the watering regime during the initial stages of growth lead me to be cautious about the results. However, if difficulty of transferring germinated seeds to the soil can be overcome, the investigation of gorse growth rates could be very profitable and directly applicable to forests where natural regeneration or planting are being considered in areas where a gorse infestation is likely after land preparation.



Photograph 6: Gorse six days after emergence. The cotyledonary leaves are plainly visible. A vertical view.



Photograph 7: Gorse twelve days after emergence. The lines on the paper are 6.35 mms apart. A vertical view showing the first leaves produced after the cotyledons.



Photograph 8: A vertical view of gorse fortysix days after emergence, showing the bushy nature of the plant at this stage. The paper is the same as that in Photograph 7.

Photograph 9: A horizontal view of the same plant as in Photograph 8 at the same stage of development.

Photograph 10: One hundred and fiftyone days after emergence showing a spindly plant beginning to resemble the mature plant.

Photograph 11: A close up picture of the terminal portion of the gorse plant in Photograph 10.

Photograph 12: A comparison of Ulex europaeus and Pinus radiata after one hundred and fiftysix days.

CONCLUSION

The gorse weevil (*Apion ulicis*)leads to a significant and very large reduction in the number of seeds that are produced by a gorse plant and is therefore a tremendous help in reducing the seed load in the soil that is capable of contributing to the gorse infestation of certain areas. However the seeds that the weevil and other agents do not destroy still enable gorse to spread as it does. One of the big problems in returning gorse infested areas to production is the germination of the seeds in the soil after clearance of the mature gorse. Any agent that helps destroy seeds, which may have a viable life from twenty-five to fifty years in the soil will be of tremendous value to future generations of land managers who try to keep land in production. For this reason, gorse weevil is a very significant insect. The literature has very little in the way of recent published work on gorse growth and biological control. The emphasis is rather on chemical control which is expensive, is generally short-term and gives variable results. Surely a long term approach is needed. *A. ulicis* lends itself to a long term method of control and to this end more work should be carried out. The gorse weevil could be reintroduced into former gorse areas which have been treated and thus help control seed production in future generations of gorse. Perhaps a small area could be left in a strategic position to enable the weevil to continue breeding, these areas could be watched to ensure a high level of weevil infestation.

The whole field of gorse and its control should be looked into very carefully and quickly, especially with respect to its physiology, growth and reproduction relative to the important exotic tree species.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Dr J.E. Barker for guidance throughout the project, to Mr D.G. Viles, forester at Ashley Forest for helpful suggestions during the sampling phase of this project, and to Messrs K.H. Schasching and P.F. Fuller for help with the photography.

BIBLIOGRAPHY

DAVIES W.M. (1928) The biomass of *Apion ulicis* Forst (Gorse weevil) with special reference to its role in the control of *Ulex europaeus* in New Zealand. Ann. Appl. Biol. 15: 263-86.

FERENS P.S. (1957) Hill Country Gorse Development. Technical Advisory officer. Ivon Watkins Ltd. New Plymouth.

MILLER D.G. (1947) Control of Gorse by Seed Weevil N.Z. Jl. Agric. 75: 341-44.

MILLER D.G. (1970) Biological Control of Weeds in New Zealand 1927-48. NZDSIR Info. Series No 74.

MOSS G.R. (1960) Gorse, a weed problem of thousands of acres of farm land. N.Z. Jl. Agric. 100: 561-7.

APPENDIX A

RESULTS OF CHI-SQUARE TESTS

NULL HYPOTHESIS — ATTACK IS INDEPENDENT OF SITE

PODS ATTACKED BY WEEVIL — Coppin Rd and HQ significantly different from other sites

PODS ATTACKED BY 'OTHER AGENTS — HQ significantly different

PODS ATTACKED BY ALL AGENTS — No significant differences

NULL HYPOTHESIS — RATIO OF NUMBER OF WEEVILS TO NUMBER OF SAMPLED PODS IS INDEPENDENT OF SITE

HQ significantly different from other sites.

NULL HYPOTHESIS — A NUMBER OF PODS WITH POTENTIALLY VIABLE SEEDS IS INDEPENDENT OF SITE

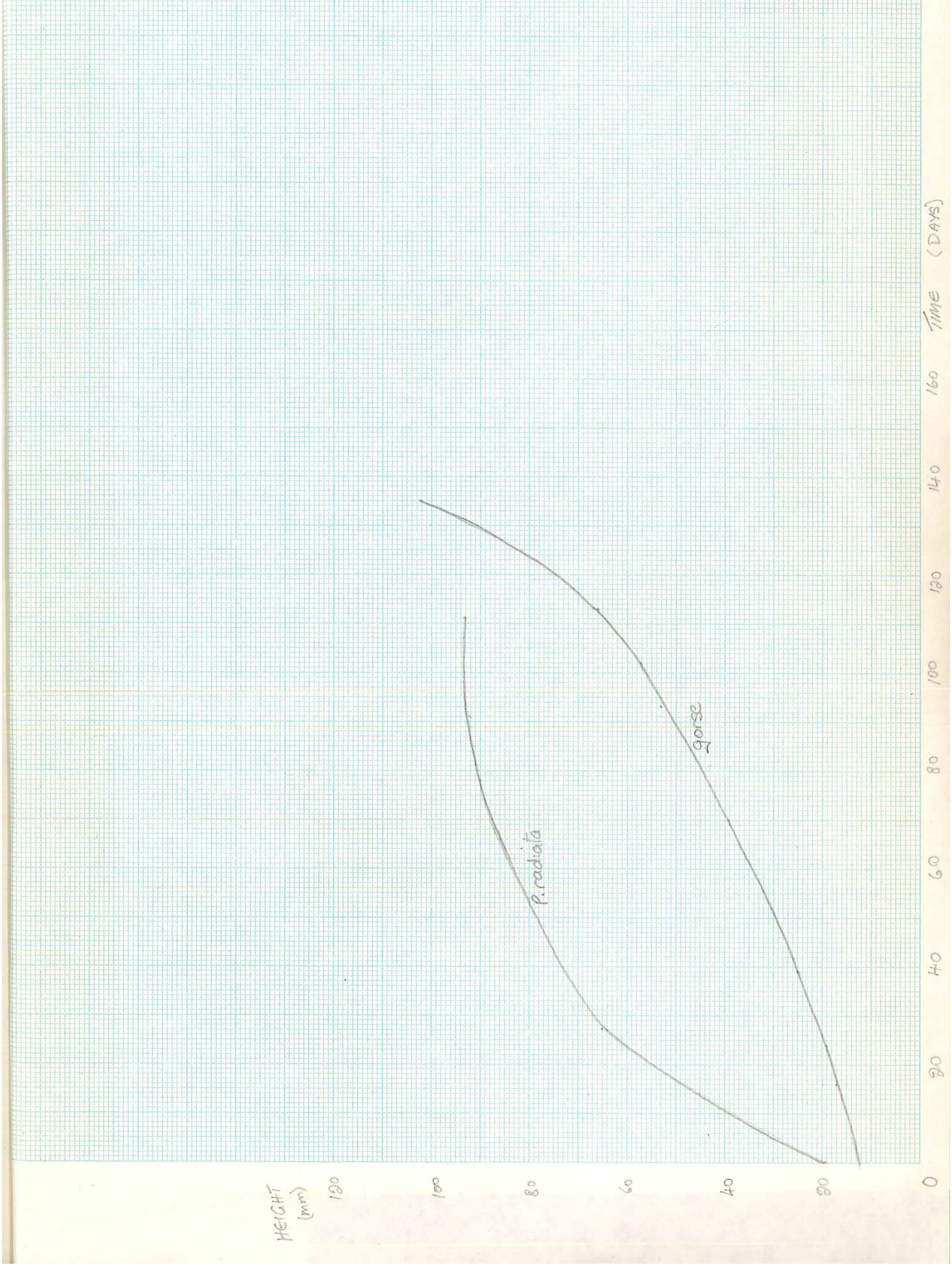
No significant differences between sites

NULL HYPOTHESIS — WEEVIL ATTACK IS INDEPENDENT OF POSITION OF POD ON GORSE BRANCH

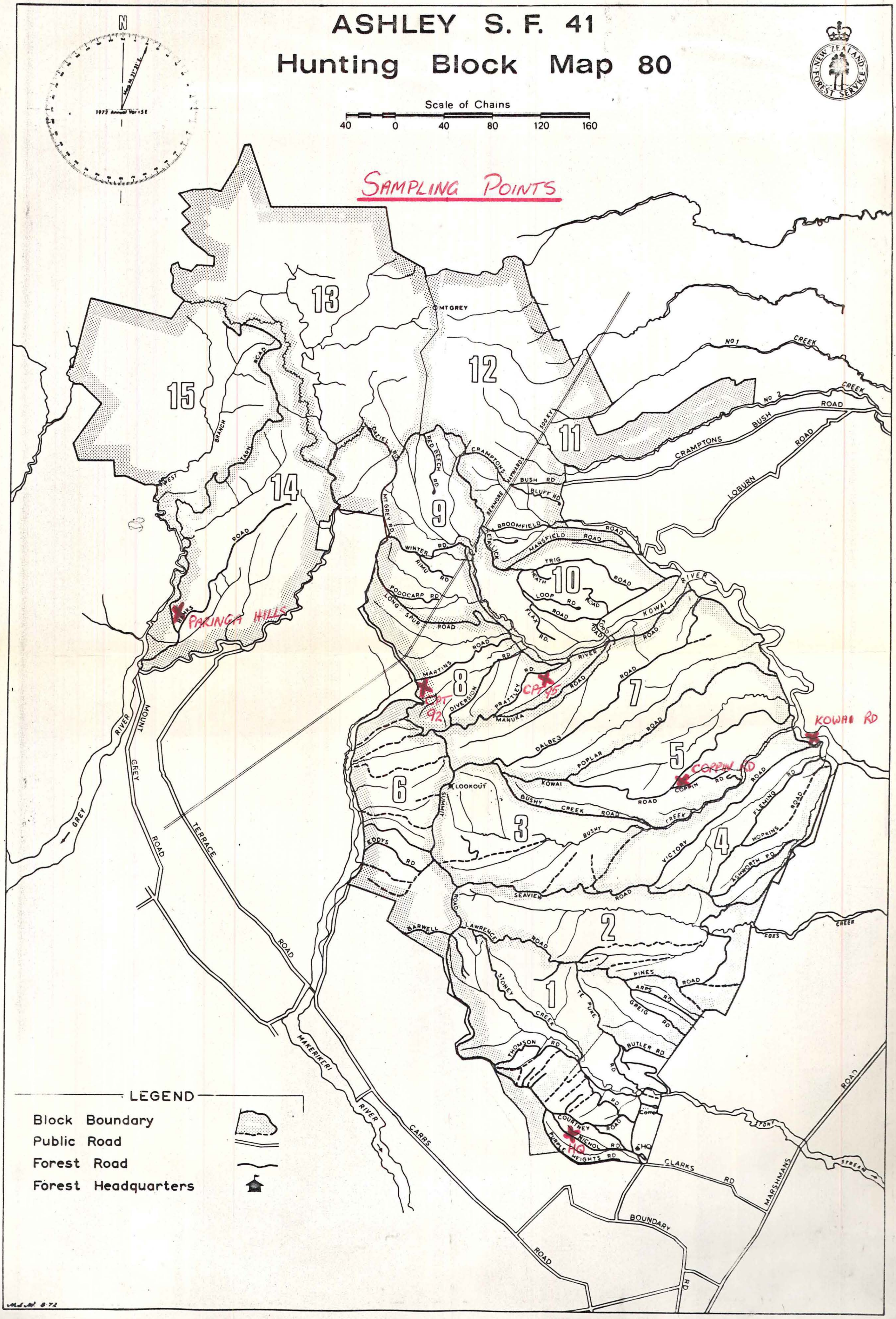
No significant differences between sites.

APPENDIX B

HEIGHT GROWTH RATES OF *P. radiata* and *U. europaeus*



APPENDIX C



ASHLEY S. F. 41
Hunting Block Map 80
Scale of Chains
40 0 40 80 120 160
N
SAMPLING POINTS
PARINGA HILLS
CPT 92
CPT 95
KOWAI RD
COPPIN RD
HQ
MT GREY
NO 1 CREEK
NO 2 CREEK
BUSH ROAD
CRAMPTONS
LOBURN ROAD
RED BEECH RD
CRAMPTONS
HAYWARDS
BUSH RD
BLUFF RD
BENMORE
BROOMFIELD
MANSFIELD ROAD
TRIG ROAD
HEATH
LOOP RD
ROAD
FLAX RD
KOWAI RIVER
FORD ROAD
RIVER ROAD
WINTER RD
RIMU RD
PODOCARP RD
LONG SPUR ROAD
MARTINS RD
DIVERSION
PRATTLEY
MANUKA
DALBES
POPLAR
KOWAI
BUSHY CREEK ROAD
COPPIN RD
FLEMING ROAD
HOPKINS
ASHWORTH RD
VICTORY
CREEK
BUSHY
SEAVIEW ROAD
LOOKOUT
SUMMIT
EDDYS RD
BARWELL
LAWRENCE ROAD
STONEY CREEK
TE PURE
PINES ROAD
ARPS RD
GREIG RD
THOMSON RD
BUTLER RD
COURTNEY ROAD
NICHOL RD
PURPLE HEIGHTS RD
CLARKS RD
BOUNDARY ROAD
MARSHMANS
STONY STREAM
FOXS CREEK
ROAD
MOUNT GREY ROAD
TERRACE ROAD
GREY RIVER
MAKERIKERI RIVER
CARRS ROAD
DAZIEL RD
MT GREY RD
STALLICK
WEST BRANCH
TARN
ROAD
BANKS
500 KV
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
LEGEND
Block Boundary
Public Road
Forest Road
Forest Headquarters