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Prickly Pear Investigations Papers transferred from markets and migration departments

PRIME MINISTER'S DEPARTMENT. No. _____

SUBJECT: PRICKLY PEAR INVESTIGATIONS.

PAPERS TRANSFERRED FROM MARKETS & MIGRATION DEPT.

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1.1 -

273

M26 44.

15th January, 1926.

MEMORANDUM -

273 ✓

With reference to your memorandum of the 6th January, No. C384/2, and previous correspondence concerning the application of the Secretary for Agriculture for the Union of South Africa for three copies of the report of the Commission which inquired into measures for the eradication of Prickly Pear, I desire to inform you that the Director of the Institute of Science and Industry communicated with the Department of Agriculture, Pretoria, on the 27th November last and forwarded the Bulletins in question.

E. J. MULVANY

per R.E.S.
Secretary.

The Secretary,
Prime Minister's Department,
MELBOURNE.

II.

The Director,
Institute of Science & Industry.

Forwarded, for information as to action taken
and for favor of return of file.

18 JAN 1926
The Secretary,
Department of Markets & Migration.

E. J. Mulvany
Secretary.
18. 1. 26.

Noted and returned with thanks.

G. H. Knibbs
Director, Institute of Science and Industry.
18/1/26

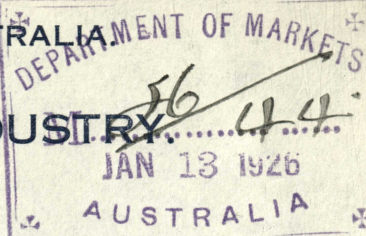
Mr Stevens 19/1

Redondo
10/1/26

COMMONWEALTH



OF AUSTRALIA



GL/BT

INSTITUTE OF SCIENCE AND INDUSTRY

Director: SIR GEORGE H. KNIBBS.

Cable and Telegraphic Address:—

INSCINDUST, MELBOURNE.

Official correspondence should be addressed to
"The Director,"and not to individual officers. Add the word
"Personal" if for the Director alone.

314 ALBERT STREET,

EAST MELBOURNE. 11th January, 1926.

In reply refer to 81

MEMORANDUM TO :—

The Minister for Markets and Migration,

MELBOURNE.PRICKLY PEAR - Re LETTER FROM SOUTH AFRICAN DEPARTMENT OF AGRICULTURE.

Knibbs

(1) Adverting to the accompanying paper on the above matter, I have to inform you that since the copy of the letter dated the 22nd October, 1925 was marked "referred" by the Secretary of your Department, it has been dealt with direct by this Institute.

(2) I wrote to the Secretary, Department of Agriculture, Pretoria, on the 27th November last, and sent him copies of the Bulletins in question.

G. H. Knibbs

683. G. H. KNIBBS

DIRECTOR.

The Secy
G. H. Knibbs
12. 1. 26

Inform P. & S. Dept. of action taken.

C.E.S.
13. 1. 26

3588

S+2 24/11

Telephone No. 5551.



WT/DA.

COMMONWEALTH OF AUSTRALIA.



C.384/2/



PRIME MINISTER'S DEPARTMENT,
DEPARTMENT OF EXTERNAL AFFAIRS.

Melbourne,

6 - JAN 1926

MEMORANDUM FOR -

The Secretary,
Department of Markets and Migration.
(Science and Industry).



I desire to invite attention to my
minute of the 23rd November, forwarding copy of letter from
the Secretary, Department of Agriculture, Pretoria, in regard
to the eradication of Prickly Pear, and shall be glad if you
will kindly expedite a reply in the matter.

Plu to S. & I. 54/11.

Mr. Stevens 7/11.



E. J. Mulvaney
Secretary.

LES/FGC.
M26/44.

II.

The Director,
Institute of Science and Industry.

Forwarded in connection with previous papers
referred on 24th November last.

E. J. Mulvaney
Secretary.

8/1/26.

14/1/26
14/1/26
9 JAN 1926

14/1/26
14/1/26

DEPARTMENT OF MARKETS AND MIGRATION

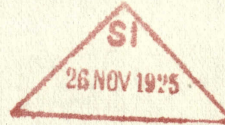
5700.

MINUTE PAPER.



SUBJECT:—

The Director,
Institute of Science & Industry,
314 Albert Street,
EAST MELBOURNE.



Referred.

E. J. Mulvaney
Secretary.
24/11/1925.



1. air Light foot

C.384/2/141.

COPY TC/ML.



UNION OF SOUTH AFRICA

PRETORIA, 22nd Oct.1925.

R.1688.

The Secretary,
Prime Minister's Department,
Melbourne.

Sir,

Eradication of Prickly Pear.

I have the honour to inform you that it is desired to obtain the latest information in regard to measures adopted for the eradication of Prickly Pear in the Commonwealth of Australia and the various scientific and other remedies for dealing with this pest. I shall be glad, therefore, if you would kindly be good enough to furnish this Department with three copies of the Report of the Commission which was appointed to go into this matter so far as the Commonwealth is concerned.

As the information is required in connection with a Resolution adopted by the Senate of the Union, I shall be obliged if the desired reports could be furnished at as early a date as possible. Any expenditure in connection with the supply thereof will be gladly defrayed by this Department.

I have, etc.

(Sgd.) G.Williams,

✓ for Secretary for Agriculture.

The Secretary,
Dept. of Markets & Migration.
(Science & Industry)

Referred for favour of early advice.

FF Deane
Secretary,
Prime Minister's Department,
12

M25 2690.

30th September, 1925.5573690.MEMORANDUM.Prickly Pear Investigations.

With reference to his memorandum of September 14th, 1925, No.C.384/2/, relative to this question, attention is invited to the memorandum dated 26th March, 1925, addressed to the Secretary by the Director of the Institute of Science and Industry intimating that Cabinet approval was given on the 22nd January, 1925, for continuation of the Commonwealth contribution of £4,000 per annum for a period of two years.

As advised in my memorandum of 20th June, 1925, No.M25/1307, the whole question regarding these investigations will receive consideration in connection with the proposed scheme of reorganisation of the Institute of Science and Industry.

res

E. J. MULVANY

Secretary.

The Secretary.

PRIME MINISTER'S DEPARTMENT.

BU. 1. 1. 26.

res

1. 10. 25

✓



TELEPHONE No.
CENTRAL 5551

TELEGRAPHIC ADDRESS:
"PRIMISTER," MELBOURNE

CABLE ADDRESS:
"KINDLIER," MELBOURNE



C.384/2/

WT/DA.
COMMONWEALTH OF AUSTRALIA.

PRIME MINISTER'S DEPARTMENT.
DEPARTMENT OF EXTERNAL AFFAIRS

Melbourne, **SEP 14 1925**

MEMORANDUM FOR -

The Secretary,
Department of Markets and Migration.

I desire to refer to your memorandum of the 20th June, No.M.25/1307, and previous correspondence, in regard to the continuance of Prickly Pear investigations, and shall be glad if you will kindly advise me of the present position of the matter.

*Mr Stevens 149
pp. My Secy's room
AES
17.9.25*

P. F. Keane
Secretary.

5553

M25 1307.

20th June, 1925.MEMORANDUM.PRICKLY PEAR INVESTIGATIONS.

With reference to his memo of June 9th, 1925, (No.C.384/2/92), and previous correspondence relative to this matter, the Secretary is informed that the question is receiving consideration in connection with the proposed scheme of reorganisation of the Institute of Science and Industry, and further advice will be forwarded at a later date.

1565 $\frac{20}{6}$ 25

Per L.E.L.

Secretary.

The Secretary,

PRIME MINISTER'S DEPARTMENT.

TELEPHONE NO.
CENTRAL 5551.

TELEGRAPHIC ADDRESS:
"PRIMISTER," MELBOURNE.

CABLE ADDRESS:
"KINDLIER," MELBOURNE.



CB/EM.

COMMONWEALTH OF AUSTRALIA.

PRIME MINISTER'S DEPARTMENT.

DEPARTMENT OF EXTERNAL AFFAIRS.

C.384/2/92.



Melbourne.

JUN 9 1925

Memorandum for --

The Secretary,
Department of Markets & Migration.

257650

I desire to again invite attention to my minute of 1st April, forwarding copy of a memorandum received from the Director of the Institute of Science and Industry, relative to the continuance of Prickly Pear investigations, and shall be glad to receive an early reply in the matter.

P. Deane
Secretary.

sur Steiner
10/6

Matter receiving consideration in connection with proposed scheme of generalisation of prohibition of further advice will be sent later



TELEPHONE NO.
CENTRAL 5551

TELEGRAPHIC ADDRESS:
"PRIMISTER," MELBOURNE

CABLE ADDRESS:
"KINDLIER," MELBOURNE

CB/NP.



C.384/2/92

COMMONWEALTH OF AUSTRALIA.

PRIME MINISTER'S DEPARTMENT.
DEPARTMENT OF EXTERNAL AFFAIRS.

Melbourne, MAY 20 1925

MEMORANDUM for --

The Secretary,
Department of Markets and Migration.

I desire to invite attention to my Minute of 1st April, forwarding copy of memorandum received from the Institute of Science and Industry in connection with Prickly Pear Investigations, and shall be glad if you will kindly advise me as to the present position of the matter.

J. B. Deane
Secretary.

*ph m25/650
bms. 2/4*

Mr. Stevens 21/5



TELEPHONE NO.
CENTRAL 5551

TELEGRAPHIC ADDRESS:
"PRIMISTER," MELBOURNE

CABLE ADDRESS:
"KINDLIER," MELBOURNE



C.384/2/92.

COMMONWEALTH OF AUSTRALIA.

PRIME MINISTER'S DEPARTMENT.
DEPARTMENT OF EXTERNAL AFFAIRS.

Melbourne. MAY 5 1925

Memorandum for --

The Secretary,
Department of Markets & Migration.

hh
M 25/650
to Mr. Stenens
7/6

I desire to invite attention to my minute of 1st April, forwarding copy of memorandum received from the Institute of Science and Industry in connection with Frickly Pear Investigations, and shall be glad if you will kindly advise as to the present position of the matter.

P. S. Deane
Secretary.

Mr. Stenens
6/5

Inform matter will be considered in connection with proposed Conference regarding the future organisation of the Institute.

R. S.
19.5.25

COPY. C384/2/92.



INSTITUTE OF SCIENCE & INDUSTRY.

EAST MELBOURNE. 26th March, 1925.

The Secretary,
Prime Minister's Department,
MELBOURNE.

re PRICKLY PEAR INVESTIGATIONS - CONTINUATION OF
SCHEME FOR TWO YEARS.

Adverting to your memorandum of the 17th instant addressed to the Acting, Secretary, Department of Markets and Migration, on the above matter, I have to inform you that Cabinet approval was given on the 22nd January last for a continuation of the Commonwealth contribution of £4,000 p.a. for a further period of two years.

Action has been taken accordingly, and at a recent meeting of the Commonwealth Prickly Pear Board arrangements were made for carrying on the work.

(SGD) G. H. KNIERS.

Director.

The Secretary,

DEPARTMENT OF MARKETS AND MIGRATION.

Referred, by direction, for favor of advice in connection with previous correspondence (M25/12).

It is presumed your Dept will advise the Director of the action taken in this matter.

P. P. Deane
Secretary

Prime Minister's Department.

APR 1 1925

Mr Stevens

See ph attached.



25/650

TELEPHONE NO.
CENTRAL 5551.

TELEGRAPHIC ADDRESS:
"PRIMISTER," MELBOURNE

CABLE ADDRESS:
"KINDLIER," MELBOURNE.



C.384/2/77

ML.
COMMONWEALTH OF AUSTRALIA.

PRIME MINISTER'S DEPARTMENT,
DEPARTMENT OF EXTERNAL AFFAIRS.

MELBOURNE,

MAR 17 1925

Memorandum for:-

The Acting Secretary,
Dept. of Markets & Migration.

I desire to invite attention to your No.M.25/12 of 5.2.25, regarding a recommendation of the Prickly Pear Board for the continuance of the agreement between the Queensland, New South Wales and Commonwealth Governments, and should be glad to be advised as to whether any further information has yet been received from the Director of the Institute of Science and Industry in connection with this matter.

J.B. Deane
Secretary

*Copy to S & I for favor of advice, 24/3/25.
Hold for reply.
24/3/25 C.C.S.*

*B1U
3/4*

India - Prickly Pear Board.

Lang Mc Constable S. & J.

~~re this~~

He informed
me that Cabinet
approved of C'wealth.

Contributing £ 4000 p.a.
for a further 2 years,
as from June 1925.

W. J. / 13/2

The Adams

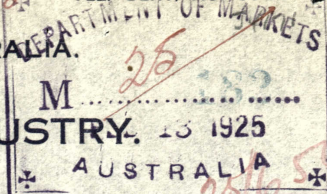
I understand this
has been approved

by the
Cabinet

and we look
to you

Telephone Johnson

8/2 12/13



RMC/LD.

INSTITUTE OF SCIENCE AND INDUSTRY.

Official correspondence should be addressed
to "The Director,"
and not to individual officers. Add the word
"Personal," if for the Director alone.

314 ALBERT STREET.

EAST MELBOURNE. December 22, 1924.

In Reply Refer to.....

FOR CONSIDERATION OF CABINET.

Prickly Pear Investigations - The financial agreement between Commonwealth and the States of Queensland and New South Wales, and an outline of work under the Scheme of Biological Control of the pest.

The biological scheme was agreed upon by the Commonwealth, Queensland and New South Wales for the eradication of the prickly pear, and came into force on the 1st June, 1920. Its control is vested in the "Commonwealth Prickly Pear Board" consisting of the Director of the Institute of Science and Industry, Sir George H. Knibbs, Chairman, representing the Commonwealth; the Under Secretary of the Department of Lands, Brisbane, Mr. A. G. Melville, representing Queensland, the Under Secretary and Director of the Department of Agriculture, Sydney, Mr. George Valder, representing New South Wales.

The official agreement required that Queensland and New South Wales should each provide £2000 a year for a period of 5 years and the Commonwealth should provide £4000 a year for the same period, thus making available yearly an amount of £8000. This agreement will terminate in June 1925.

The tentative period of 5 years for the work was decided upon by having regard to the time involved in a world-journey of the investigators and the breeding and acclimatisation of the insects which was ascertainable only after actual trials. The present proposal is for an extension of the time for a period of 2 years, with the same contributory basis as in the original agreement, Queensland and New South Wales having signified their approval, provided that the Commonwealth will co-operate.

The chief reasons for this proposed extension are the following:-

A number of insects, e.g. cochineals (*Dactylopius* spp.), moths with boring larvae (*Melitera* and *Mimorista*) and cactus bugs (*Chelinidea*), have been introduced from America and are now successfully acclimatised in Australia. They have given some proof of their power to destroy prickly pear, and have been tested and found to be non-injurious to a large number of economic plants. The breeding of these on a large scale is being undertaken for an effective distribution of the insects in selected prickly pear areas, and some measure of distribution is already in progress.

The investigation of numerous insects both in Queensland and U. S. A., and the insect surveys of the prickly pear areas of America, indicate that there are other insects well worth introducing. This can be done only while the present organisation is in existence for that special purpose.

A number of fungi are known to be very destructive to cacti in North and South America. It is considered advisable to study them abroad and to introduce cultures of them for use in additional control of pear in Australia.

On the initiation of the scheme of biological control a central laboratory was established at Sherwood, Brisbane, where all imported material is received and examined and the insects propagated. Subsidiary laboratories were established at Westwood and Chinchilla in

Queensland and at Biniguy (now at Gravesend) in New South Wales. Each laboratory is in charge of an officer trained in the work at Sherwood, the entomologist in charge of the whole being Mr. W. B. Alexander, M.A., with headquarters at Sherwood. The Board has also established a laboratory at Uvalde in Texas and an Australian entomologist from Sherwood is now in charge of the American investigations. He has two assistants.

The work in America consists mainly in the collection, propagation, elimination of parasites and the despatch of certain specified insects; the survey of insects causing damage to prickly pear and the testing of the range of food plants (especially economic) of such insects dealt with under the Board's scheme. Special attention is now being paid to insect enemies of the pear fruit as no successful introduction of such insects has been made.

Approximately 30 species of insects have been introduced into Australia; a few have since died out, but the majority are now acclimatized. Many have been tested on about 60 kinds of economic plants to determine the possible range of plants to which they might be injurious.

Two species of cochineal insects (*Dactylopius* spp.) have been introduced, one (*D. confusus*) attacks *Opuntia monacantha* only, whereas the other (*D. tomentosus*) attacks three (3) of the worst pest-pears in Queensland, viz. *O. inermis*, *O. stricta* and *O. tomentosa*. Three (3) strains of the latter known according to their place of origin as the Arizona, Texas and the Chico (California) cochineals have been tested in five (5) localities in Queensland and two in New South Wales, to determine their relative destructiveness to the different species of pear. Liberation of these insects commenced in February last.

Arrangements are now completed for the distribution of the following:- *Mimorista flavidissimalis*, *Melitera junctolineella*, and three (3) species of *Chelinidea*, at selected localities near the laboratories.

Having regard to past experience and the rate of progress attained, it is believed that it is necessary to continue the work till June 1927 in order to ensure the successful development of this method of attack on the pest. To stop now would gravely jeopardise it. £40,000 will have been spent and it is believed the expenditure of £16,000 more of which the Commonwealth would find one-half, would achieve the full establishment of the method.

G. H. KNIBBS.

DIRECTOR.



GL/MMG.

COMMONWEALTH



OF AUSTRALIA.

TEL. CENT. Nos. 184.
185.
186.

B20/857

INSTITUTE OF SCIENCE AND INDUSTRY.

In Reply

Refer to

8/1

DANKS' BUILDINGS,

391 BOURKE STREET,

MELBOURNE.

2nd. February, 1920.

MEMORANDUM TO:-

The Acting Comptroller-General,
Department of Trade & Customs,
MELBOURNE.



PRICKLY PEAR ERADICATION.

Herewith/

In connection with the accompanying papers on the above matter (T & C. B. 857) I desire to state as follows:-

Herewith/

1. The effect on the prickly-pear of every known plant poison has been exhaustively enquired into (see pages 26 to 32 of accompanying Bulletin). It was ascertained that compounds of arsenic, and especially arsenious chloride, are undoubtedly the most efficacious and economical poisons.

2. If Mr. J.H. Green is willing to disclose, in confidence if desired, complete information regarding his specific, its cost, methods of preparation and use, together with particulars of any experiments carried out, we shall be glad to give further consideration to the matter.

Gerard Lightfoot

CHIEF OFFICER.

FEB 3 REC

The Secretary,
Prime Minister's Department.

Forwarded in pursuance of your minute of the 21st January herein.

LM

A.M. Dabney

Acting Comptroller-General.

5/2/20.

COMMONWEALTH



OF AUSTRALIA

Institute of Science and Industry

BULLETIN No. 12.

THE PRICKLY PEAR

IN AUSTRALIA

Published under the authority of
THE EXECUTIVE COMMITTEE
of the Advisory Council of Science and Industry.

MELBOURNE, 1919

BY AUTHORITY:
ALBERT J. MULLETT, GOVERNMENT PRINTER, MELBOURNE

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COMMONWEALTH



OF AUSTRALIA

Institute of Science and Industry

BULLETIN No. 12

The
PRICKLY PEAR
IN AUSTRALIA

By
W. B. ALEXANDER, M.A.
Science Abstractor.

Published under the authority of
THE EXECUTIVE COMMITTEE
of the Advisory Council of Science and Industry.

MELBOURNE, 1919

By Authority:
Albert J. Mullett, Government Printer, Melbourne,

LIST OF ILLUSTRATIONS.

PLATE I.—Map of Part of Queensland and New South Wales showing area infested with Prickly Pear Facing page 13

TEXT FIGURES—

	PAGE
1. Flowers and developing fruit of the Spiny Pest-Pear	8
2. The Pest Pear (<i>Opuntia inermis</i>) showing dense Pear in Brigalow Scrub ..	9
3. Spiny Pest Pear or Gayndah Pear	10
4. Tree Pear (<i>Opuntia monacantha</i>) 18 feet high	11
5. The Pest Pear (<i>Opuntia inermis</i>) showing dense Pear in open forest country	14
6. Jointed Cactus (<i>Opuntia aurantiaca</i>)	16
7. Plot of Prickly Pear before treatment with arsenic acid	29
8. Plot of Prickly Pear after spraying with 2·5 per cent. solution of arsenic acid (half-a-gallon of solution per approximate cwt. of pear)	29
9. Clump of Tree Pear (<i>Opuntia monacantha</i>) growing at Charters Towers ..	34
10. Remains of the clump shown in Fig. 9 a year after the introduction of the Wild Cochineal Insect (<i>Coccus indicus</i>)	35
11. A Cactus Longicorn Beetle (<i>Moneilema crassum</i>)	38
12. One of the Cactus Weevils (<i>Gerstæckeria nobilis</i>)	39
13. <i>Opuntia engelmanni</i> , showing a black exudation from some of the areoles, due to the presence of the larvæ of a Cactus Weevil (<i>Gerstæckeria nobilis</i>)	39
14. A Cactus Moth (<i>Melitara prodenialis</i>)	40
15. Segment of an <i>Opuntia</i> showing the work of the larvæ of a Moth, <i>Mimorista flavidissimalis</i>	40
16. Wild Cochineal (<i>Coccus confusus newsteadi</i>) on <i>Nopalea cochinelifera</i> ..	42

LIST OF CONTENTS.

	PAGE
Synopsis	5
A. THE PRICKLY PEAR—	
1. Prickly Pears	7
2. Species of Prickly Pear naturalized in Australia	8
3. Introduction of Prickly Pears into Australia	11
4. The Spread of Prickly Pears in Australia	12
5. The Area infested with Prickly Pear in Australia	13
6. Rate and Methods of Spreading	14
7. Prickly Pears in other Countries	15
B. UTILIZATION OF PRICKLY PEAR—	
1. As Food for Man	17
2. As Fodder for Cattle	17
3. Spineless Prickly Pears	19
4. Prickly Pear as a Green Manure	22
5. As a Source of Alcohol	22
6. Utilization of the Fibre	23
7. As a Source of Potash	24
8. Other Possible Uses	24
C. METHODS OF ERADICATION—	
1. Eradication by Mechanical Means	26
2. Eradication by Poisoning—	26
(a) Arsenic Acid	30
(b) Arsenious Chloride	31
(c) Arsenious Acid	31
(d) Summary	32
3. Eradication by the Employment of Natural Enemies—	32
(a) Destruction of Tree-Pear by Cochineal Insects	33
(b) Other Natural Enemies of Prickly Pears	34
(c) Diseases of Prickly Pears	42
(d) Destruction of Prickly Pear by Overgrowth	43
D. CONCLUSION : REPORT AND RECOMMENDATIONS OF THE EXECUTIVE COMMITTEE OF THE ADVISORY COUNCIL	
Appendix I.—Sources of Information and Bibliography	46
Appendix II.—Notice to Users of Arsenious Chloride as to Precautions desirable in handling, and the best Remedies in case of accidental poisoning	48

SYNOPSIS.

Prickly pears are plants belonging to the cactus family, indigenous to the American continent. A number of species have become acclimatised in Queensland and New South Wales, and several are serious pests. Much the worst is that called the Pest Pear (*Opuntia inermis*), which has occupied over 22 million acres of land in Australia, and is estimated to be spreading at the rate of a million acres a year.

Owing to its tenacity of life, its armature of prickles and spines, and its succulent nature, the prickly pear plant is extremely difficult to eradicate. The cost of eradicating pear by manual labour from land thickly infested is prohibitive, except where the land is exceptionally valuable, and in consequence many methods have been suggested whereby the cost might be reduced. These suggested methods fall into two groups—

1. Those in which it is proposed to find commercial uses for the pear and thereby pay the whole or part of the cost of clearing the pear-infested land.
2. Those in which it is proposed to utilize special machinery, poisons, or natural enemies to destroy the pear.

A considerable amount of research has been carried out in the past in Queensland and New South Wales on almost all the proposed remedies for prickly pear.

Of the great number of ways suggested for utilizing the pear, the only one which has proved satisfactory is that of feeding it to stock. By the addition of various additional feeding stuffs satisfactory rations for cattle and "dry" sheep, consisting chiefly of prickly pear, can be provided. Breeding ewes and lambs, however, do not do well on pear. If all the cattle in Australia were fed entirely on prickly pear it is doubtful whether they would be able to keep pace with its annual increase alone, hence as a means of eradicating the pest from Australia its utilization for stock is not very helpful.

The manufacture from prickly pear of alcohol, paper or cardboard, potash, and various other materials has been suggested, but in all these cases the fact that prickly pear consists very largely of water makes its profitable commercial utilization very unlikely.

No satisfactory machine for destroying prickly pear has yet been invented, and the problem, owing to the bulk of the material, is a very difficult one.

Greater success has been achieved in the search for poisons, and as a result of a very large number of tests it has been established that compounds of arsenic are the most useful poisons, being specially toxic to prickly pears. Arsenic acid is the most deadly compound for use in solution as a spray or by injection, but, unfortunately, it is practically unobtainable in Australia. Arsenious chloride is at present the chemical chiefly in use, and is applied either as a spray or in the form of gas where the pear is impenetrable. Arsenate of soda, being cheaper and less dangerous to handle, is still used to some extent, but necessitates the use of large quantities of water in making solutions, and at least two sprayings are required to kill the pear.

No method has yet been discovered by which prickly pear can be cleared for less than from £2 10s. to £4 an acre. Even if all land of this value were cleared, great quantities of poorer land covered with pear would remain to serve as a constant menace to the cleared land, on to which the pest would constantly tend to spread. Chemical or mechanical means for destroying the prickly pear are at best only temporary measures, except in cases of land under cultivation. Thousands of acres in Queensland which have been cleared have subsequently been re-infested. In all cases mechanical or chemical clearing necessitates continuous work of some kind for keeping the land clear. It is therefore obvious that mechanical or chemical treatment is of little real value in dealing with the pest from a national stand-point.

The only method which has been suggested whereby the plant might ultimately be destroyed is by the employment of natural enemies, and it is only by the introduction of such enemies that even the land which is now clear can be considered safe from further serious infestation. A large number of kinds of insects are known which feed exclusively on one or more kinds of prickly pear, and in the absence of pear cannot survive. In their native countries these insects are kept in check by their enemies and parasites, but it is not impossible that if introduced into Australia where their natural enemies do not exist they might cause havoc amongst the prickly pear plants. The only insects of this type yet introduced to Australia are certain wild cochineal insects which feed on the so-called tree pear (*Opuntia monacantha*). In a few years this kind of pear has been practically exterminated in every area to which the insects have been introduced. Unfortunately, however, this insect cannot be induced to attack the Pest Pear. Amongst the other insects referred to, it is quite possible that some would be found as destructive to this species as the wild cochineal has proved to be to the Tree Pear.

Further inquiries in this direction are urgently required, and it is hoped that with the aid of funds provided by the Commonwealth and the States of Queensland and New South Wales the Institute of Science and Industry will be able to take up this work, which, if successful, would be the means of ridding Australia from the most formidable enemy of the agricultural and pastoral industries.

The Prickly Pear in Australia.

BY W. B. ALEXANDER, M.A.

A.—THE PRICKLY PEAR.

1. Prickly Pears.

To the dweller in many parts of Queensland and New South Wales it may seem quite unnecessary to start a paper on Prickly Pears by describing what is meant by this term. Fortunately, however, there are still parts of Australia where prickly pears are unknown, and, in case any dweller in those regions looks into this bulletin, it seems desirable at the outset to explain the main features of the plants with which it deals.

Prickly pears then are plants of American origin, belonging to the cactus family (*Cactaceæ* of botanists). They are practically leafless shrubs, the place of the leaves in the economy of the plant being filled by green flattened branches. These are often incorrectly called "leaves" in ordinary parlance, being usually flattened and more or less oval in form, but the term "joint" or "slab" is preferable. The true leaves of the plant are represented by certain fleshy scales found on the young branches or joints which are present in some numbers in some species and varieties, but are scarce in others, and in any case are usually shed when the joint is full-grown. Scattered regularly over the joints and fruits of the plant are spots or areas often depressed, known botanically as areoles, from which spring spines and bristles, and at the base of each of which is a growing point from which a new joint or a flower may develop.

The spines are needle-shaped and often very powerful. They may occur singly or there may be a group of several springing from each areole. In a few species spines are almost absent. These so-called spineless pears are referred to again in a later section (p. 19).

Though the spines are formidable and in some species are strong enough to penetrate a stout boot-sole, they can be seen and usually avoided, and are not feared nearly so much by those who have to deal with prickly pear as are the bristles. These latter, technically called glochidia, occur in tufts in the areoles, and in some species also cover the whole plant, including the fruit, more or less completely. They are often so fine that they are not easily seen, but, being barbed, when once they enter the skin or the clothing they are not easily removed and cause serious irritation to man and beast. If the blood be in an unhealthy condition, very serious irritation, and even illness, may result from these aggravating bristles.

The flowers of prickly pears (Fig. 1) are fairly large and are usually yellow. In different species the yellow may be of various tints, sometimes almost white, in other cases deep orange. Occasionally they are scarlet, pink, or carmine.

The fruits are usually about the size of a plum and are either spheroidal, barrel-shaped or pear-shaped, hence the name prickly pear. The tough outer skin is usually carmine when the fruit is ripe, but it may be purple, orange, or cream-coloured. The fleshy interior in which the seeds are embedded is usually carmine, but it may be almost white or orange. This pulp is palatable in some species, and in certain countries prickly pears, particularly the so-called Indian Fig (*Opuntia ficus-indica*), are cultivated for their fruit.

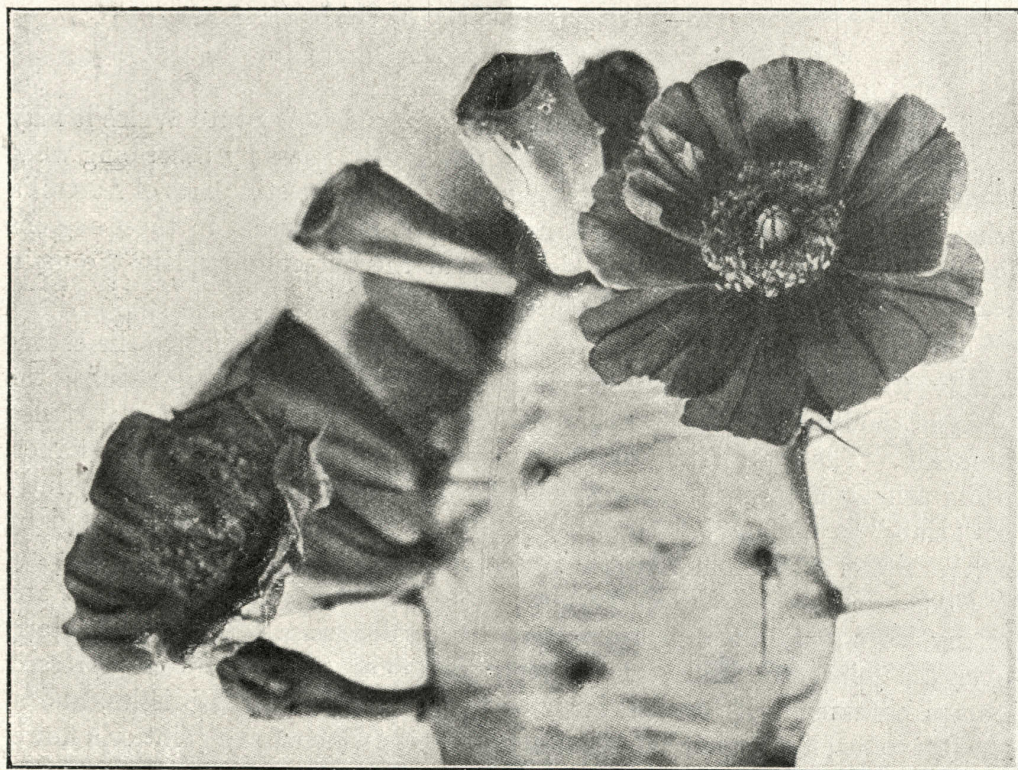


Photo., Dept. Agriculture, Brisbane.

Fig. 1.—Flowers and developing fruit of the Spiny Pest Pear, from Gracemere, Queensland. (From the Q'nd. Prickly Pear Travelling Commission's Report. Fig. 6.)

The whole prickly pear plant is eminently drought-resistant, the reduction of the leaves, and the tough cuticle of the leaf-like joints, being adaptations to prevent the loss of moisture from the plant. In addition many species have a swollen subterranean continuation of the stem, commonly called a "bulb," and even if the whole plant above ground is killed or perishes in a severe drought, the "bulb" will usually survive and give rise to new branches.

2. Species of Prickly Pear Naturalized in Australia.

Over a dozen distinct kinds of prickly pear have escaped from cultivation in Australia and become naturalized in smaller or larger areas. Of these we need only consider three at the present time, since, though some of the others are firmly established in particular localities, they are not as yet serious pests over

any considerable area. Descriptions of all the species known to have become naturalized in Australia, with excellent coloured illustrations, and details of the localities in which they have been reported, are given by Mr. J. H. Maiden, F.R.S., in a series of papers published in *The Agricultural Gazette of New South Wales*, 1911 to 1917, entitled "The Prickly Pears of Interest to Australians."*

The species which has spread over millions of acres of land in Queensland and New South Wales and is on this account known in Australia as the "Pest Pear," or simply as "Pear," has been identified by Mr. Maiden as a form of *Opuntia inermis*. The differences from the true *O. inermis* which it exhibits are probably due to changes, perhaps in the nature of adaptations to local conditions, which have come about since its introduction into Australia.



Photo. by A. T. Clerk, Lands Dept., Brisbane.

Fig. 2.—The Pest Pear (*Opuntia inermis*), showing dense pear in Brigalow Scrub.

The Pest Pear forms a dense comparatively low growth, though in certain situations it may attain a considerable height. Spines are usually few, and there is only one springing from each areole. The flowers are lemon-yellow,

* The Prickly Pears of Interest to Australians, J. H. Maiden—

No. 1—*Opuntia aurantiaca*, Gillies, *Agricultural Gazette of New South Wales* XXII., 1911, p. 321. No. 2—*Opuntia imbricata*, Haw. XXII., 1911, p. 696. No. 3—*Opuntia nigricans*, Haw. XXIII., 1912, p. 208. No. 4—The Pest Pear of New South Wales and Queensland (*Opuntia inermis*, P.D.C., var.) XXIII., 1912, p. 713. No. 5—The Velvety Prickly Pear (*Opuntia tomentosa*, Salm.-Dyck.) XXIII., 1912, p. 1027. No. 6—The so-called "Indian Fig" or "Barbary Fig" (*Opuntia Ficus-indica*, Mill.) XXIV., 1913, p. 49. No. 7—The Pear-fruited Prickly Pear (*Opuntia monacantha*, Haw.) XXIV., 1913, p. 863. No. 8—*Opuntia dejecta*, Salm.-Dyck., syn. *Nopalea dejecta*, Salm.-Dyck. XXIV., 1913, p. 973. No. 9—Dillenius' Prickly Pear (*Opuntia Dillenii*, Haw.) XXIV., 1913, p. 1073. No. 10—The Golden-bristled Prickly Pear (*Opuntia microdasys*, Lehm.) XXV., 1914, p. 137. No. 11—Queensland Prickly Pear A (*Opuntia* sp.) XXV., 1914, p. 519. No. 12—The Cochineal Cactus (*Opuntia cochinillifera*, Mill. or *Nopalea cochinillifera*, Salm.-Dyck.) XXV., 1914, p. 883. No. 13—A Scone Prickly Pear (*Opuntia* sp.) XXVI., 1915, p. 489. No. 14—*Opuntia brasiliensis*, Haw. XXVIII., 1917, p. 486. No. 15—*Opuntia vulgaris*, Mill. XXVIII., 1917, p. 650.

sometimes tinted orange; the fruits are pear-shaped, often curved, about 2 inches long, purple or crimson externally, with crimson flesh.

A second species of prickly pear which covers considerable areas of country in several parts of Queensland may be called the Spiny Pest Pear or Gayndah Pear, Gayndah being the locality in which it is worst. (See Fig. 1, p. 8). This has been identified as *Opuntia Dillenü* by Mr. Maiden, but Prof. T. H. Johnston and Mr. H. Tryon state that the Australian form is different from the *O. Dillenü* of other countries. It is possible, as in the Pest-pear, that these differences are modifications produced by Australian conditions. This



Photo by A. T. Clerk, Lands Dept., Brisbane.

Fig. 3.—Spiny Pest Pear or Gayndah Pear.

is a rather dwarf species, of scrambling habit, with from three to five large yellow spines springing from each areole and contrasting strikingly with the tufts of black bristles at their bases. The flowers are yellow and the fruits red-purple, and they are generally produced from the edges of the joints.

The third species which seems worthy of special mention is that known as Suttor River Pear or Tree Pear in Queensland, where it sometimes attains a height of 18 feet. The botanical name of this species is *Opuntia monacantha*, and it has become naturalized in all the Australian States, though up to the present it is nowhere a very serious pest. This species grows into a large plant with a distinct stem and, especially when young, the joints are more or less pendulous. The spines are long and very strong, white with brown tips, often single but sometimes in groups of two or more. Bristles are rare on the joints but numerous on the fruits. The flowers are yellow

with reddish suffusion on the outside of the petals, the fruits are pear-shaped, green with a crimson blush or suffusion externally and greenish-yellow within.



Photo. by A. T. Clerk, Lands Dept., Brisbane.

Fig. 4.—Tree Pear (*Opuntia monacantha*), 18 feet high.

3. Introduction of Prickly Pears into Australia.

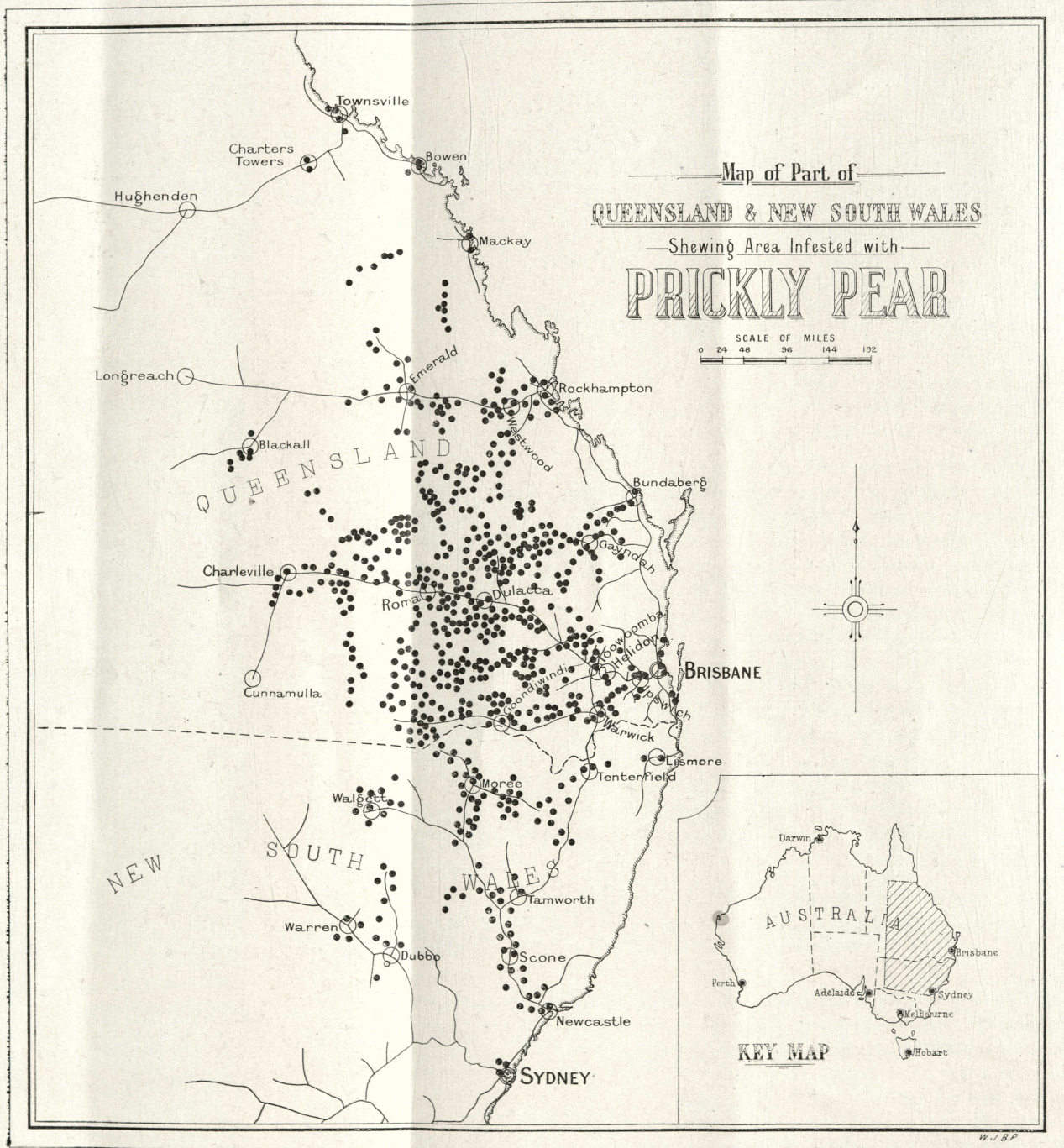
At the period when Australia was first colonized the British Government was anxious to establish the cochineal industry in British dominions, cochineal being at that time a monopoly of the Spanish and Portuguese. Cochineal is a red dye derived from the cochineal insect, or *Grana fina* (*Coccus cacti*), which insect lives exclusively on certain species of prickly pear.

Accordingly, the East India Company prepared a garden of prickly pears at Madras, growing them from plants obtained from the Royal Gardens at Kew through Sir Joseph Banks. The species grown was *Opuntia monacantha*. In 1788 the company gave sealed orders to the captains of some of its ships proceeding to Brazil to procure the cochineal insect if possible and carry it to India. It appears probable that Sir Joseph Banks must have suggested the possibility of establishing the cochineal industry in the new settlement at Botany Bay; at all events when Captain Phillip, on his way out to establish the settlement, called at Brazil he obtained some cochineal insects and prickly pear plants on which to feed them. The next port of call was the Cape, and Captain John Cox, who had previously visited the prickly pear (*O. monacantha*) garden at Madras, wrote to Dr. J. Anderson, who had formed the garden: "The insect was fixed on the plant under a very white down, and Commodore Phillip, who brought both from South America with him, did not wish that either should be in the least disturbed. Having had an opportunity of inspecting both the cochineal, as well as the prickly pear on which it is cultivated, I find that they resemble both as nearly as possible that I have seen in your garden, except that the prickly pear appeared to me to have many more thorns and to be not nearly so luxuriant."

We have no information as to what was done with the prickly pear and cochineal insects when the expedition landed at Sydney in 1788. Mr. Maiden thinks that the prickly pears naturalized about Sydney are descended from Governor Phillip's plants. The two species which he mentions as being found near Sydney are *Opuntia monacantha* and *O. inermis* (the Pest Pear), but Captain Cox's evidence would suggest that Governor Phillip's plant was more spiny than either of these. It is possible, therefore, that Governor Phillip's plants died, and that our present Australian prickly pears have all been introduced subsequently. This seems all the more probable since more than forty years later Mr. James Busby, in his work on the Culture of the Vine in New South Wales, published in 1832, advocates the introduction of prickly pear hedges similar to those of Spain into New South Wales, so that it is evident that prickly pears were not common near Sydney at that date. Mr. Maiden states that many years ago people used to claim the honour of having introduced species of prickly pear into Australia as useful plants, but he adds that their descendants are now silent on this point.

4. The Spread of Prickly Pears in Australia.

Though it is known that a number of species of prickly pears were cultivated in gardens and even used in the formation of hedges in Australia many years ago, yet it was not till about 1870 that they appear first to have got beyond control. The centre from which the Pest Pear spread in New South Wales was Scone, about 200 miles north of Sydney. The plant is said to have been brought there by Dr. Carlisle soon after 1839 as a rare plant in a pot. It was grown in a station garden, whence the manager carried it about and established it in various paddocks, with the idea that it would be a good stand-by for stock in a drought year. Prickly pear first came to Queensland (or, as it then was, New South Wales) in 1848 or 1849, in the Warwick district, the plant being among others obtained from Sydney for



garden purposes, a strong recommendation accompanying it as a fruiting and hedge plant. Later prickly pear plants were sent up by a Sydney firm to another station in the same district with a similar recommendation. From these centres the Pest Pear seems to have spread far and wide. There appears to be no evidence as to the mode of origin of the other pears, but there is little doubt that they began as garden escapes, and that the first few plants being overlooked or neglected, they established themselves so firmly as to defy eradication.

5. The Area Infested with Prickly Pear in Australia.

Though, as already mentioned, the Tree Pear has become naturalized in all the Australian States it is at present only in Queensland and New South Wales that prickly pears have become a pest.

The Lands Departments of these two States have kindly supplied information as to the districts infested with prickly pear at the present time, from which the accompanying map (Plate I.) has been prepared. The black dots indicate the districts infested, and their relative abundance or scarcity in different areas indicates the relative thickness of the infestation in different localities.*

The areas actually infested are estimated as follows :—

Queensland	..	..	over 20,000,000 acres
New South Wales	..	..	about 2,208,000 acres

The total area of pear-infested land in Australia is thus over 22,208,000 acres, or 34,700 square miles. This is considerably larger than the State of Tasmania, 26,215 square miles. It is actually over 1 per cent. of the total area of the Commonwealth. Nearly 5 per cent. of the area of Queensland and over 1 per cent. of New South Wales are pear-infested.

The area under prickly pear contrasts with the areas under the principal crops in Australia in 1916-17 as follows :—

Crop.					Area in Acres.
Prickly Pear	...	..	..	..	22,208,000
Wheat	..	..	..	..	11,532,828
Hay	..	..	..	..	2,671,862
Oats	..	..	..	..	844,130
Green Forage	..	..	..	..	390,876
Maize	..	..	..	..	360,072
Orchards and Fruit Gardens	..	..	..	..	257,687
Total under Crops	..	..	..	..	16,806,380

The degree of infestation varies, but when once the pear becomes firmly established it often forms an almost continuous covering over many acres of land. The photographs of thickly-infested pear land in Southern

* I am indebted to Mr. W. J. B. Percival for his careful preparation of this interesting map from the data supplied by the Departments.

Queensland, reproduced in Figs. 2 (p. 9) and 5, give a good idea of such areas, and incidentally indicate the extreme difficulty of clearing the land. There is a prevalent impression that prickly pear grows chiefly on poor land, but this is by no means the case, as the pear does not flourish in very poor soil, and much of the infested area is good land—for instance, land in the Hunter Valley, New South Wales, and on the Darling Downs in Queensland.



Photo. by A. T. Clerk, Lands Dept., Brisbane.

Fig. 5.—The Pest Pear (*Opuntia inermis*), showing dense pear in open forest country.

6. Rate and Methods of Spreading.

The rapidity at which the prickly pear spreads, and is still spreading, can perhaps be sufficiently gauged by the fact that it has overspread some 23,000,000 acres in less than 50 years.

Particulars of an actual instance where the rate of spread was officially observed have kindly been supplied by the Lands Department of New South Wales. The Mungle Scrub in the Warialda district of that State contains about 42,000 acres. A traverse of the area was made in 1908, and certain surveys were carried out in the same locality in 1910. It was discovered that in the intervening two years the pear had advanced about half a mile in a solid mass on a frontage of about four miles.

The methods by which the pear spreads are two: by the growth of new plants from joints or unripe fruits which have become detached from the parent plant, and by the germination of seed.

Slabs and fruits are readily detached from the plants, and may be carried for considerable distances down streams in time of flood or by cattle travelling along the stock routes.

The ripe fruits are eaten by cattle and by various species of birds. The seeds pass through the intestines without injury and subsequently germinate in the droppings of the animals or birds. The birds which are the principal agents in distribution of the seeds appear to be the emu, crow, and black magpie (*Strepera graculina*). Mr. H. L. White, of Scone, N.S.W., has in his possession several emu droppings containing prickly pear seeds from which young plants are growing, and similar specimens have been figured by Mr. G. P. Darnell-Smith.* In several localities the birds mentioned above are destroyed owing to the fact that they are regarded as agents in distributing prickly-pear seed. No proper inquiry seems to have been made, however, as to whether the harm they may do in this way is compensated by their value in other directions, and there is little doubt that cattle and horses are more important agents in spreading the pear than birds. The Brush Turkey (*Cathetura lathamii*) has also been credited with spreading the plant, but after careful experimental investigation Mr. G. B. Brookes has ascertained that though the birds feed freely on prickly pear fruits, their powerful gizzards crush the whole of the fruit so thoroughly that practically no seeds capable of germination reach the bird's intestines.†

7. Prickly Pears in Other Countries.

Australia is by no means the only country where prickly pears have become a pest. They have been introduced into most countries in the warmer parts of the world, and almost everywhere soon tend to take possession of vacant land. In India and the countries bordering on the Mediterranean with their dense populations the pear is comparatively easily checked from encroaching on good land and confined to waste land; but in the southern United States and South Africa, which, like Australia, are countries with a comparatively sparse population, the pear has become a formidable menace in some districts. In South Africa two species, *Opuntia decumana* and *O. aurantiaca*, have become serious pests. One of these, the Jointed Cactus (*O. aurantiaca*) (Fig. 6) is established in the neighbourhood of Roma, and in other parts of Queensland and New South Wales, and in view of South African experience it is most desirable that this species should be extirpated before it becomes a pest in Australia.

A great deal of valuable information as to the prickly pears found in different countries, their enemies, the possibilities of their utilization and the methods used for destroying them, is contained in the report of the Queensland Government's Prickly Pear Travelling Commission.‡ This Commission,

* Darnell-Smith, G. P. Animal Aids to the Spread of Prickly Pear. *Agricultural Gazette of New South Wales*, XXX, p. 125, Feb. 1919.

† Brookes, G. B. Report on Investigations in Regard to the Spread of Prickly Pear by the Scrub Turkey. *Queensland Agricultural Journal*, XI., p. 26, Jan. 1919.

‡ Queensland Parl. Paper C.A. 91-1914. Government Printer, Brisbane.

which consisted of Prof. (then Dr.) T. Harvey Johnston, of the Biology Department of the University of Queensland, and Mr. H. Tryon, Government Entomologist and Vegetable Pathologist, travelled all round the world in the years 1912 to 1914 studying these questions. Much of the information collected by them is referred to in later parts of this bulletin.

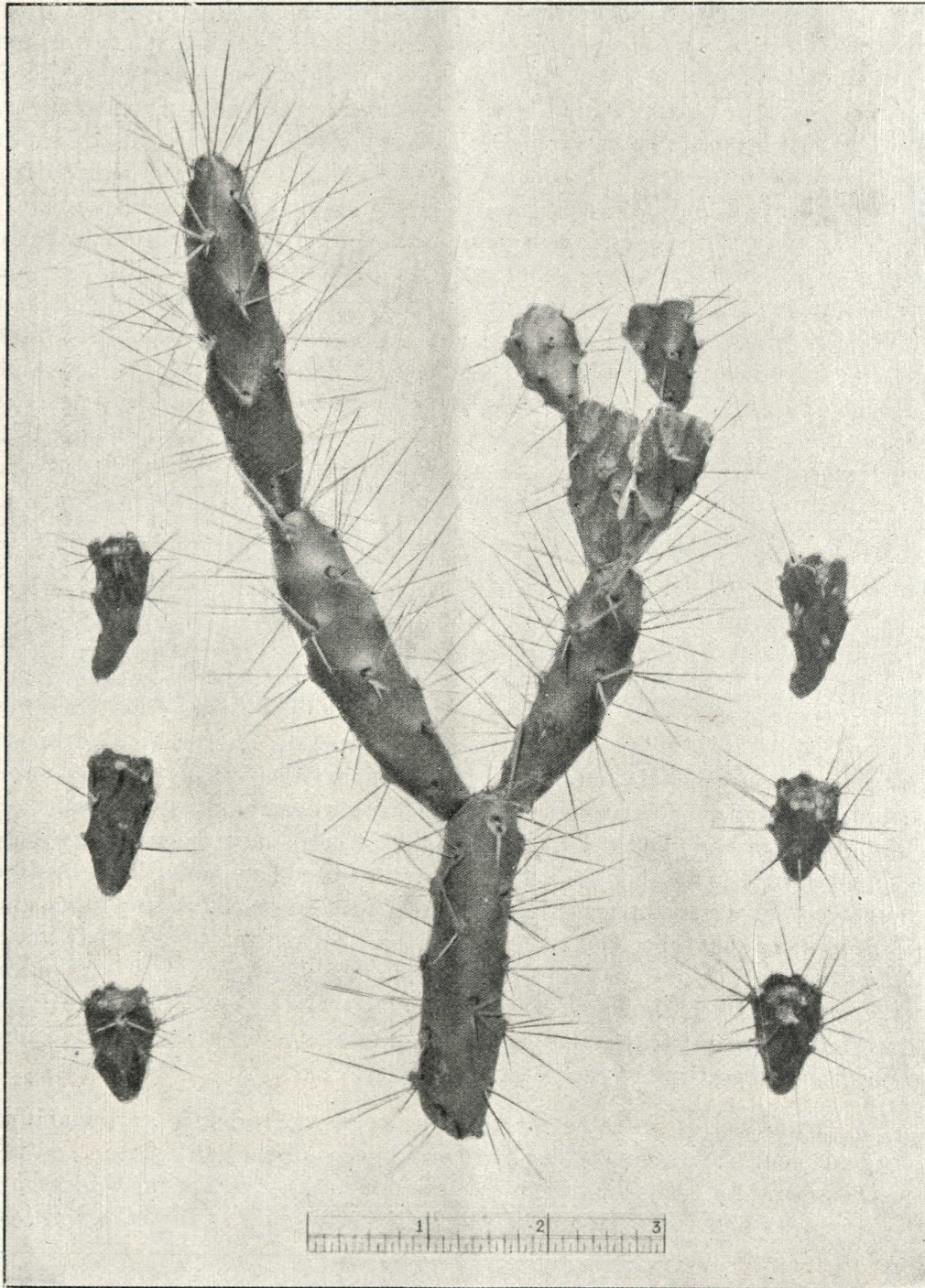


Photo., Dept. Agriculture, Brisbane.

Fig. 6.—Jointed Cactus (*Opuntia aurantiaca*), from Roma, Queensland. Segments and fruits. (From Q'nd. Travelling Commission's Report. Fig. 24.)

B.—UTILIZATION OF PRICKLY PEAR.

1. As Food for Man.

The fruits of species of prickly pear are used by the inhabitants of many countries. In the Mediterranean region the Indian Fig or Barbary Fig (*Opuntia ficus-indica*) is largely cultivated for its fruits. In different parts of Italy and on the islands of Sicily and Sardinia, the Indian Fig is grown on rocky hillsides which cannot be utilized for other crops, and the fruit finds a ready sale in the markets of Naples and other cities. The plants are planted at the rate of 2,178 plants to the hectare (about $2\frac{1}{2}$ acres), and the yield per hectare is calculated as averaging 220,000 fruits per year. The plants continue to bear for from 30 to 50 years.

In Tunis a hectare is stated to yield 20,000 kilos (about 20 tons) of fruit (figs) annually. The fruit is very nutritious, and during four months of the year the Arabs live almost exclusively upon it and grow fat. This species is also cultivated for its fruit in the Canary Islands.

In South Africa the fresh ripe fruit of *Opuntia decumana* forms an important part of the food supply of the natives and the "poor whites." Sometimes the fruit is dried or converted into preserves, jams or jellies.

In Mexico, also, the fruits of prickly pears are largely used for food, especially those of the "cardona" (*Opuntia streptacantha*). These are chiefly eaten in the fresh condition, whilst those of other species are dried in the same manner as figs or apricots, and may be eaten dry or after boiling in water. The fruits of a number of North American species of cactus have been analyzed, and it has been shown that they contain from 3 to 10 per cent. of sugar in the juice, though it is stated that by selection and cultivation fruits containing as much as 24 per cent. of sugar can be produced.

Various food products are manufactured from the fruits by the Mexicans, including a syrup or "honey" called miel, a "cheese" (queso), and a fermented drink called colonche.

Fermented drinks are prepared from the juice of prickly-pear fruits in many other countries.

2. As Fodder for Cattle.

The Pest Pear (*Opuntia inermis*) was originally spread at Scone, and subsequently at Warwick, to form a reserve of fodder in case of drought. There is no question that it has considerable value for this purpose, remaining green and succulent in the driest season, and being readily eaten by stock. Experience has shown, however, that prickly pear by itself does not contain sufficient nutriment to keep up the condition of animals fed upon it. The fruits are much more nutritious than the joints.

In order to form a balanced ration some more concentrated fodder, such as lucerne, bran, cotton-seed meal or oil-cake should be added. The composition of several such rations has been published in India, Italy, the United States and elsewhere. For a 1,000 lb. milch cow it has been suggested in America that the ration might consist of 50 lbs. of prickly pear, 10 lbs. of wheat bran, and 10 lbs. of lucerne; or of 40 lbs. of prickly pear, 10 lbs. of wheat bran, and 12 lbs. of corn stover, the nutritive ratio being 1 : 5.4, which is the standard European ratio for dairy cattle. In India it has been found

that when cotton-seed has been incorporated with prickly pear to the extent of constituting 6 per cent. of the weight of the mixture, not only will the cattle subsist on the ration, but they will regain condition should they have become poor from semi-starvation, the average daily consumption being 72 lbs. of prickly pear per 1,000 lbs. live weight. In Sardinia and elsewhere dry grass or foliage and small branches of certain edible trees are added to the prickly pear.

It has been proved experimentally that succulence, owing to its influence on lactation, is an important factor in fodder for cattle, especially milch cows. The presence in the ration of the succulent under consideration, viz., prickly pear, not only had no detrimental effect on the composition of the milk, but, on the other hand, led to an increase in quantity, without any depreciation in quality, so that there was a very distinct gain in regard to the total yield of dairy products.

The amount of pear used per animal daily, along with other food, varies in the United States from 40 to 70 lbs. If more than this be employed there is a likelihood of scouring. Some preparation of the pear is generally necessary, the amount varying in the case of the different species. As a rule the stems and joints are singed and chopped up, various forms of torches having been devised for singeing the spines. In some cases, however, cattle are turned into the paddocks to feed on the plants after they have been singed.

Since the Pest Pear of Australia is comparatively spineless, cattle will feed on it without previous singeing, though this usually results in the lips becoming swollen, sometimes to such an extent that the animals cannot eat for some days till the swelling subsides. On this account a preliminary treatment of the pear is desirable, and another grave objection to allowing cattle to feed directly on the growing plants is that in the process they break and trample them down and thus tend to spread the pear over the paddocks.

Prickly pears of different species vary to some extent in their composition and the Queensland Government's Travelling Commission therefore recommended that experiments, similar to those carried out in other countries, should be made in Queensland to determine the exact feeding values of the commoner forms of prickly pear in Australia. This recommendation was adopted by the Government, and a Prickly Pear Stock-feeding Experiment Station established at Wallumbilla in 1915 under the control of Mr. F. Smith, B.Sc., F.I.C.

A summary of the results of the experiments carried out at this station was published by the Queensland Department of Agriculture and Stock in 1918.*

Four main series of experiments were carried out, namely, the feeding of prickly pear to steers, dairy cattle, calves, and sheep; the prickly pear used being the common pest pear (*Opuntia inermis*). The following were the chief conclusions arrived at.

* The Feeding of Prickly Pear to Stock. A Bulletin for Stock-owners compiled by the Prickly Pear Board from the result of experiments conducted and reports submitted by Frank Smith, B.Sc., F.I.C. (Assistant Chemist). Queensland Dept. of Agric. and Stock. 1918.

Prickly pear requires treatment prior to feeding to stock. It may be harvested, sliced by hand or machine, and fed in troughs; or it may be singed, roasted, or boiled. In practice the method of boiling was found to be the least satisfactory. Sliced prickly pear is not injurious to the health of stock generally.

Prickly pear is not highly palatable to either steers, dairy cows, calves, or sheep. Its chief utility is as an emergency feed in time of drought. Sliced by a suitable machine it can be supplied at about 6s. per ton for cattle feed, or 8s. per ton in the form recommended for sheep.

For the full maintenance of stock, prickly pear requires to be supplemented by protein-supplying feeds such as linseed meal, cocoa-nut oil cake, maize oil meal, lucerne or cowpea (hay or chaff). With the requisite supplementary feeds at normal market prices, the cost of prickly pear maintenance rations is not excessive.

The inclusion of appreciable quantities of prickly pear in rations for milch cows lowers the percentage of butter fat and reduces the total fat yield, but it may slightly increase the flow of milk. The butter fat yielded by pear-fed cows is comparatively pale in colour, but the quality of the product is not otherwise affected. The milk is suitable for cheese-making purposes. For milch cows it is more advantageous to utilize pear in part as the roughage ration than to make it the sole roughage and to feed in high amounts.

Prickly pear is a suitable feed for cows in calf, provided the deficiency of protein is added. Weaned calves can be maintained during sustained dry spells on a ration of prickly pear and suitable meals or legume hays.

Prickly pear is serviceable as part of the maintenance ration for "dry" sheep, but the ration fed must include some kind of rough chaff. It is unsuitable for ewes rearing lambs, or for lambs. The trials with sheep indicate that blood-meal can be used instead of linseed or other meals to provide the necessary protein.

Stock at large naturally prefer pear plants showing the greatest freedom from prickles and spines. Pear-eating cattle running at large must have access also to edible scrub or herbage supplying protein.

During the trials it was found that in hot weather all stock fed with prickly pear required water.

3. Spineless Prickly Pears.

It seems desirable to refer briefly to the so-called "spineless" cactus, a variety said to have been produced by Luther Burbank, the famous Californian plant-breeder, as this plant has been widely advertised throughout the world as a plant suitable for growing as a fodder for stock in arid regions.

The "spineless cactus" is merely a practically spineless form of the well-known Indian fig, *Opuntia ficus-indica*, referred to earlier in this Bulletin. Mr. J. H. Maiden* states that specimens obtained from Mr. Burbank are in no way different from plants which have been in the Sydney Botanic Gardens for very many years.

* Maiden, J. H., in *Agricultural Gazette* of New South Wales, 2nd January, 1913, p. 54.

It is claimed for Mr. Burbank's forms that they are not fibrous, and hence can be used as a vegetable. The young "joints" of many species and varieties contain but little fibre, but as they grow older they develop the usual network of strong fibre. Mr. Maiden states decidedly that many plants in the Sydney collection are just as non-fibrous as any of Luther Burbank's that he has seen, and points out that if the plant were non-fibrous it would be more valuable as a food for stock than as a vegetable.

Analyses of Burbank's "spineless cactus," *Opuntia ficus-indica* var. *inermis*, grown in the Argentine, are as follows* :—

PERCENTAGE COMPOSITION OF THE JOINTS OF "SPINELESS CACTUS."

Substances.	In the Green State.	Dried at 100-105° C	In the Dry Substance.
Moisture	83·000	2·899	..
Ash	4·098	23·432	24·12
Proteins	2·266	12·950	13·34
Fats	0·328	1·876	1·93
Carbohydrates	8·071	46·125	48·01
Cellulose	2·227	12·730	13·10
	99·990	100·012	100·50

The nutritive ratio varies from 1 : 4 to 1 : 4·5.

On the 16th October, 1912, twenty varieties of spineless prickly pears (*Opuntia*) were planted at Nyngan Demonstration Farm, N.S.W., for the purpose of ascertaining—

- (1) Their suitability to local conditions.
- (2) Their liability to revert to a more spiny form.
- (3) Their economic value.

Nyngan is in a dry country area, 382 miles west of Sydney, with a 17-inch rainfall, and the plants were obtained from the Sydney Botanic Gardens, and planted in well-prepared ground.

In May, 1917, Mr. J. H. Kelly, the manager of the farm, reported on the experiment as follows† :—

"From time of planting until July, 1913, the weather conditions were favorable to plant growth, owing to good rainfall during that period. All the plants struck and made fair headway.

From July, 1913, to April, 1916, very dry conditions were prevalent, only occasional showers fell, yet it is worthy of note that every plant survived, and practically all continued to make fair growth. At times, however, when the conditions were exceedingly dry, they would display a withered appearance, but immediately rain fell, or even if the atmospheric conditions became moist, they would revive and again look fresh and healthy.

* D.-Girola, C. Tunas sin espinas consideradas como plantas forrajeras. Publicn. del Museo Agrícola, Buenos Aires, No. 7, 1917.

† Maiden, J. H. The Cultivation of "Spineless" Prickly Pear. *Agricultural Gazette of New South Wales*, 2nd Oct., 1917, p. 740.

In March, 1916, just prior to the break-up of one of the most severe periods of drought on record, some sheep were turned into the paddock where the Opuntias were growing. After eating all other available vegetation, including the foliage of several salt bushes of the Old Man variety, they commenced to nibble at the Opuntias. In a few instances the plants were eaten down; the majority were eaten but slightly.

From April, 1916, to February, 1917, the rainfall was abundant. The whole of the plants made growth, and some attained a height of 6 feet, with a breadth of almost the same measurement.

In February, 1917, the conditions again becoming dry and continuing so, sheep were again placed in the paddock in April, and, after eating all other green vegetation, took to the Opuntias again, practically eating the lot down. The lower and harshest parts of the plants were all left uneaten.

Although these plants would probably thrive better in warm, moist climates, their suitability to local conditions has been amply proved by their having lived and made satisfactory growth through a most severe drought—that of 1914-15-16. That trial has proved, undoubtedly, their qualities of drought resistance.

At the commencement of growth, most plants developed small spinules on the joints, but not in a very marked degree, and not sufficient to be harmful to stock. No ill effects have been noticed on the sheep which recently ate down the plants. Later growths are not perceptibly more spiny than were the earlier. The fruit, however, has always been very spiny (covered with spinules).

As a fodder plant, its cultivation cannot be recommended for this district. Even the fruit, as an article of diet, has little or no value; and neither plant nor fruit is ever likely to be worthy of cultivation from this point of view. The only quality in its favour that may be spoken of is its power to withstand prolonged periods of drought, but when compared with such plants as Old Man saltbush, its virtues are reduced to a negligible quantity.

When grass and herbage are too scarce or too dry to alone sustain stock, any plant that will withstand prolonged droughts and provide nourishment is worthy of recognition as a reserve fodder, but Opuntias fail to give the same satisfaction as saltbush, which is a quicker grower and supplies a better balanced and much more highly nutritious food. Other uses may ultimately be found which would justify further trials, but at present there are no indications of the Opuntias having any special virtues that cannot be derived from other sources from which no danger exists of their ever becoming a pest."

Every reasonable person must agree with Mr. Kelly's conclusions. It is one thing to endeavour to utilize the prickly pear, itself not very spiny, which is already in possession of the land, but quite another thing to introduce another similar species, rather less spiny, for the identical purpose for which the pest pear was introduced.

If only those who introduced prickly pears to Australia had devoted their attention to the preservation and propagation of the salt-bushes and other fodder plants already growing on their estates, instead of trying to bring in a foreign fodder-plant, their stock would probably have done better, and Australia would have escaped the worst of all its introduced plagues.

4. Prickly Pear as a Green Manure.

Prickly pear has been used to considerable advantage in Ceylon, India, South Africa, and Mediterranean countries, and occasionally in Australia, as a green manure. A method found to be very satisfactory in India consists in digging series of wide trenches, almost filling them with broken plants, and then covering the latter with a layer of earth some 18 inches or 2 feet in thickness. Any new growth which makes its appearance above ground is, of course, removed and buried. In many localities the joints are distributed over the field and then turned under in the same fashion as other leaf manures.

After several months the pear becomes converted into humus, whilst potash is also added to the soil by this means. Lands so treated have given much better crops than untreated areas, but in Australia the pear has been little used for this purpose. In the western districts of Queensland where, owing to the climate, the soils are generally deficient in humus, this mode of utilization is well worthy of extension.

5. As a Source of Alcohol.

It has already been mentioned, in discussing the utilization of prickly pear for food, that various fermented drinks are prepared from the fruits in different countries. This has led on several occasions to the proposal being made that the fruits of prickly pears should be used for the manufacture of industrial alcohol.

The manufacture of alcohol from the fruit was tried in Granada, Spain, some years ago, but it was not a commercial success owing to the heavy excise imposed on alcohol by the Spanish Government. Attempts have also been made to utilize the fruit for this purpose in Sicily, but they were not commercially successful owing to the heavy excise and the fact that the fruits have a considerable market value in that country.

The question has been investigated in the United States, and it was ascertained that if fruits have an average of 10 per cent. of sugar, then 140 lbs. of fruit are needed to produce one gallon of alcohol. In order to render this a profitable undertaking, it is necessary (1) that there should be a large production of fruit per acre, about 10 tons per acre being needed; and (2) that there should be some rapid and cheap means of collecting the fruit, as gathering by hand, even in Texas and New Mexico where cheap native (Mexican) labour is available, is far too expensive.

Under these circumstances it seems very improbable that the industry could be a commercial success in Australia.

Proposals have been made from time to time in Australia, South Africa, and other countries, to manufacture alcohol from the green parts of prickly pear plants. Alcohol can, of course, be manufactured from any materials containing sugar or starch, *i.e.*, from any vegetable substance, but any material which can serve as a profitable source for the production of industrial alcohol must contain a sufficient percentage of sugar or its equivalent to pay for the handling and treatment of the material. Analyses of the pest pear, *Opuntia inermis*, carried out in Queensland by Mr. J. C. Brunnich, Chemist to the Department of Agriculture, showed that the total sugar content calculated as dextrose was 0.64 per cent. Experimental work in the

production of alcohol from prickly pear under as perfect conditions as possible for the fermentation and distillation gave a yield of alcohol equal to 0.5 per cent. of the weight of the plant used.*

When the cost of labour for cutting and collecting pear, the cost of crushing and fermenting, and finally the cost of concentrating alcohol from such a dilute solution as 0.5 per cent. of spirit, are all taken into consideration, the problem does not appear to be capable of economic successful solution.

6. Utilization of the Fibre.

The possibility of using the fibre contained in prickly pear for the manufacture of paper or board has often been mooted, and a number of experts have tested it for the purpose and in every case reported adversely. As regards the utilization of green prickly pear, the remarks of the Director of the Imperial Institute, London, in a report to the Queensland Government, sum up the position concisely.

Professor Dunstan says that experiments at the Imperial Institute have shown that a pulp can be prepared by the process of heating the fibres of the plant with caustic alkali under pressure, but that the product so obtained consists of very short fibres (about 1/80th to 1/30th inches long), and would, therefore, be of comparatively low value. It is probable that the collection of the raw materials would be a costly operation. Moreover, a little consideration will show that an immense quantity of the plant would have to be dealt with in order to produce a comparatively small amount of paper pulp. Analyses of various parts of the prickly pear at different ages in the United States of America† have shown that, on the average, the fresh plant contains 84.3 per cent. of water and 2.4 per cent. of crude fibre. Experiments at the Imperial Institute have proved that 100 parts of dry prickly pear fibre yield about 42 parts of dry paper pulp. Hence from 2.4 parts of the crude fibre about one part of pulp could be obtained. It is evident, therefore, that for the manufacture of 1 ton of paper pulp it would be necessary to collect about 100 tons of the fresh plant. When to the cost of collecting and handling this mass of material is added that of the chemicals and labour required for the extraction of the fibre and its conversion into paper pulp, it seems evident that the project could not possibly be remunerative, especially as the product is of low quality and would not in any case be worth more than a few pounds per ton.

Any treatment for the destruction of prickly pear which will rob the plant of its high water content will obviously increase the percentage of fibre in the remainder. The value of this fibre, if it were suitable for pulp manufacture, would then lower the cost of destruction of the plants. In view of these considerations the Queensland Government submitted a sample of the residuum of the killing of the prickly pear by poison to Messrs. Sindall and Bacon, of London, the well-known paper experts. This firm reported as a result of its experiments that the only possible method of treatment would be to boil the prickly pear residuum without any previous mechanical separation of the non-fibrous portions. This treatment could be effected in

* See Power-Alcohol, Commonwealth Advisory Council of Science and Industry, Bulletin No. 6, 1918, p. 34, for a fuller discussion of this subject.

† U.S. Dept. of Agriculture, Bureau of Plant Industry, Bulletin 102, Pt. 1, 1907.

open pans, using weak caustic soda solution as the re-agent, so that the chemical process would be easily and cheaply carried out. It would then be necessary to add chemical wood pulp to the extent of 25-30 per cent. to produce a paper pulp which would have any value at all. Such boards as would be obtained in this way can be easily manufactured, and should prove serviceable for packing fruit and similar goods for shipment. This appears to be the only outlet for the material, as it is quite out of the question to attempt to manufacture it into ordinary papers. The question of cost of treatment and the ultimate cost of the finished board would have to be very carefully investigated. The very low yield of 20 per cent. from the original residuum renders the whole process a questionable one.

Mr. A. E. Clarke, Chemist to the Australian Paper Mills Company Limited, Melbourne, investigated similar material in 1918, and reported that the amounts of chemicals required in preparing pulp from it were very high and that the paper made from the pulp was greatly deficient in strength owing to the shortness of the ultimate fibres, the inferior felting qualities of the fibres, and the large proportion of non-fibrous cells. He remarks that the prospects of using vegetable growths containing excessive qualities of moisture for pulping are in general very poor.

The question as to whether prickly pear can be profitably converted into paper pulp or board must therefore be answered in the negative.

7. As a Source of Potash.

In most processes for the destruction of prickly pear, the ultimate method is to burn the plants. This can only be done some months after they have been killed owing to the large amount of water contained in the joints, and it is generally necessary to mix dry branches and scrub with the dead pear for the purpose. The ash left after burning is over 10 per cent of the weight of the dry material, and nearly half of the ash consists of potash salts.

It has been suggested that it would pay to collect the ash from land on which dense prickly pear has been killed and burned and extract the potash from it. This has been attempted on a considerable scale by Mr. O. C. Roberts on behalf of Cactus Estates Limited at Dulacca, but it is understood that it was not a financial success. It seems doubtful whether the amount of potash available would pay for the cost of collection and extraction, especially as it is difficult to collect the ash without obtaining considerable amounts of soil at the same time. Probably the best method of utilizing the potash is to leave it on the soil, where its presence must be beneficial to plant-growth on the cleared land whether crop or pasture.

8. Other Possible Uses.

The mucilage from prickly pears is used in India as an addition to white-wash and in the preparation of a plaster for the interior of buildings. Investigations in America indicate that a 10 per cent. solution is very viscous but has poor adhesive qualities, and is unsatisfactory as a glaze for paper. Even if a use were found for this substance for some special purpose, it seems improbable that more would be required annually than could be obtained from the plants on a few acres.

The magenta colouring matter contained in the fruits of some prickly pears is used in various countries for minor purposes, *e.g.*, in Sicily as a dye for basketware, and in Mexico to colour various beverages and foodstuffs. It is very improbable that its utilization in Australia will ever prove to be of any economic importance.

Prickly pear hedges are frequent in certain parts of the world, but in view of past experience they should be strongly discouraged in Australia. In a few parts of the world where trees are very scarce prickly pears serve as fuel, but the difficulty of burning them has already been mentioned as one of the difficulties in the way of eradicating them from Australia.

Oxalate of lime is specially plentiful in prickly pears, crystals of this salt being found in all parts of the plant. It has been suggested that this might be extracted and used for the manufacture of oxalic acid, but it is doubtful whether this process could compete with the present process of the manufacture of oxalic acid from sawdust, since in the latter case the raw material is a waste product obtainable in large quantities.

The products obtained from prickly pear by the process of destructive distillation have been investigated by Dr. F. H. Campbell.* The gas produced differed in composition according to the conditions of distillation, but had a calorific value of about 13 B.T.U. per cubic foot. The liquid distillate, crude tar, and charcoal were constituted as follows:—

PRODUCTS OBTAINED BY DISTILLATION OF PRICKLY PEAR (*O inermis*).

Product.	Per cent.	Lbs. per Ton.
Water	88.4	1,980.1
Acid (as acetic)	0.154	3.45
Ammonia, primary and secondary amines (as ammonia)	0.005	0.11
Tertiary amines (as pyridine)	0.071	1.59
Crude tar	1	22.4
Charcoal	4	89.6

The liquid distillate was a dilute solution of acetic acid contaminated with tarry substances. The crude tar had very little tenacity, and when fractionally distilled yielded only traces of substances other than water at temperatures below 150° C. The charcoal remaining in the retort was clean and extremely porous, retaining the shape of the original material.

Taking the price of calcium acetate (crude) at 8d. a lb., that of pyridine (refined) at 4s. 6d. a lb. and that of charcoal at 20s. per ton, it is found that the value of the products per ton of green plant is approximately 8s. It is considered extremely doubtful that this would cover the cost of clearing the ground. The value of the gas produced has not been taken into consideration in calculating the value of the products, as it would be most profitably used in assisting to heat the retort.

* The Destructive Distillation of Prickly Pear. Report of Australasian Assn. for the Advancement of Science, vol. XIV., p. 104, Melbourne, 1913.

C.—METHODS OF ERADICATION.

1. Eradication by Mechanical Means.

In country which is only slightly infested with prickly pear, where perhaps there are a few plants along the edges of a paddock or round the trees, which have sprung up from seeds dropped by birds, the plants should immediately be rooted up by hand labour, laid on a pile of brushwood and burnt. If this were carried out immediately pear appeared in a new locality by every land-owner, and by local authorities where plants appear on the roadsides, it would in the long run be well worth the cost entailed. Too often the first few plants which make their appearance are regarded as negligible, when a very slight amount of labour would destroy them, and in a few years the land-owner is faced with a formidable task.

The well-known advice given by a farmer to his son to keep on planting trees which would be growing while he was sleeping may well be borne in mind. The prickly pear plant is too often allowed to grow while the local councils and land-owners sleep, with the result that it produces fruit and its seeds are spread to new localities. "Eradicate it at once" should be the motto of every land-owner who has a single prickly pear plant on his property.

If the plant has spread sufficiently to form clumps, it usually pays best to poison the plants by one of the methods referred to in the next section before digging them out and burning. In all cases special care should be taken to eradicate the plants thoroughly, especially in localities where the underground "bulbs" are common, and every piece of green joint should be picked up, since a new plant will otherwise grow from it.

A great many methods for the mechanical destruction of pear, other than by grubbing it out, have been suggested from time to time, and some fairly elaborate machines have been devised and some of them constructed and tested. Up to the present none of these machines have fulfilled the hopes of their inventors, and it is therefore unnecessary to refer to them further here. On good land, fairly heavily infested, it frequently pays to roll down the prickly pear and either collect and burn it, or plough it in for green manure. The rolling is done with a heavy log, to which a team of bullocks is attached by chains in such a way that the log works at one side of the team. In cases where farmers have teams and labour which for the time being are not required for other work, a piece of prickly pear land is often cleared in this way.

2. Eradication by Poisoning.

Poisoning of pear by chemical means is the method generally used for clearing. This method is usually less expensive than mechanical clearing, except in cases where labour is available in an off season, when its cost may be regarded as nominal.

In order to determine the cheapest and most efficient methods of poisoning prickly pear, an exhaustive series of experiments was carried out at Dulacca by Dr. Jean White (afterwards Dr. White-Haney), on behalf of the Queensland Government in the years 1912 to 1916.* In these experiments the effects of all known plant-poisons on prickly pear were ascertained, and the best methods of applying those which proved effective were determined.

* See Appendix IV. of Annual Reports of Department of Public Lands, Queensland, for the years 1912, 1913, 1914, and 1915.

Five methods of applying poisons were tested, viz. :—

- (a) Injection of a solid specific.
- (b) Injection of a liquid specific or solution of specific.
- (c) Spraying of a specific or solution of a specific over the aerial part of the plant by means of an ordinary spray pump.
- (d) Spraying of a specific or solution of a specific over the aerial parts of the plant by means of an atomiser pump.
- (e) The evolution of gas or vapour charges over the aerial parts of the plant.

These methods of application are all important, according to circumstances.

The injection method is probably the surest and most inexpensive, and has the advantage that none of the poison is wasted. It is, however, only applicable in localities in which the pear is distributed as scattered plants.

Spraying is the most convenient way of dealing with scattered clumps of pear, but the effects produced are far more variable than they are when the injection method is adopted, owing to the variability of external conditions, whilst some of the poison is inevitably wasted.

When dealing with dense impenetrable pear the evolution of poisonous vapours is the only possible method of destruction. This method suffers from the same disadvantages as spraying, and, in addition, it is dependent on the weather, since a very light breeze in the desired direction is necessary if the best results are to be obtained.

The following table gives in alphabetical order the substances which were found to be more or less injurious to prickly pear in the Dulacca experiments, the method of application in each case being indicated by a cross.

Materials more or less injurious to Prickly Pear.

	Solid Injected.	Liquid or Solution Injected.	Liquid or Solution Sprayed.	Used as Gas or Vapour.
Antimony chloride	—	×	×	—
Arsenic disulphide	—	—	—	×
Arsenic pentoxide and mixtures and compounds containing it	×	×	×	—
Arsenic sulphide and caustic soda	—	×	×	—
Arsenic trichloride and mixtures and compounds containing it	—	×	×	×
Arsenic trihydride	—	—	—	×
Arsenic trioxide and mixtures and compounds containing it	×	×	×	×
Barium chlorate	—	×	—	—
Cacodylic acid	—	×	—	—
Chlorine	—	—	—	×
Chloroform	—	×	×	—
Copper sulphate	×	—	—	—
Ferrous sulphate	×	×	—	—
Formaldehyde	—	×	—	—
Lysol	—	×	—	—
Mercuric chloride	×	×	×	×
Mercuric oxycyanate	×	×	—	—
Phenol	—	×	×	—

Materials more or less injurious to Prickly Pear—continued.

			Solid Injected.	Liquid or Solution Injected.	Liquid or Solution Sprayed.	Used as Gas or Vapour.
Phosphorous (yellow)	×	—	—	—
Potassium bichromate	×	—	—	—
Potassium chlorate	×	×	—	—
Potassium cyanide	×	×	—	—
Potassium sulphocyanide	—	×	—	—
Sodium cacodylate	×	×	—	—
Sodium chlorate	×	×	—	—
Sodium sulphite	×	—	—	—
Sulphur dioxide	—	—	—	×
Sulphuric acid	—	—	×	—
Zinc chloride	×	×	×	—
Zinc sulphate	×	×	—	—

Some of the foregoing injurious materials were disregarded as being too expensive for general use, and after many further experiments the majority of the others were rejected as not being sufficiently deleterious.

It was ascertained that compounds of arsenic are undoubtedly the most efficacious and economical poisons, and during the last year of the experiments only the three following specifics were given further trials, viz. :—

Arsenic acid (crude arsenic pentoxide).

Arsenious chloride (arsenic trichloride).

Arsenite of soda and salt (arsenic trioxide, caustic soda and common salt).

Compounds of arsenic are undoubtedly specially toxic to prickly pear. The spraying or gassing of pear-plants has a temporary effect on the neighbouring vegetation, but this soon recovers; the prickly pear, on the other hand, if effectually sprayed, will rot away, though usually a few pieces remain alive and start to grow again. Before they can make much headway, however, the remainder of the plant is usually dry enough to be collected and burnt, when final destruction is assured.

It is not only the parts of the plant above ground that are killed by arsenic, but the root is also destroyed and rots in the ground. By far the most resistant part is the "bulb," which is not readily destroyed.

The fear having been expressed that the utilization of arsenical poisoning for clearing pear might harmfully affect crops subsequently grown on the cleared land, experiments were undertaken at Dulacca to test this point. Crops of wheat and lucerne, raised on plots on which pear had been poisoned with arsenic, burnt and dug in, did better than crops raised on land from which the pear had been removed without poisoning. Analyses of the plants grown on land where pear had been poisoned showed that no appreciable quantities of arsenic had been absorbed by them, so that it is fairly certain that the arsenic does no harm to subsequent crops, and that the burnt poisoned pear when dug in is distinctly beneficial.



Fig. 7.—Plot of Prickly Pear before treatment with Arsenic Acid.



Fig. 8.—Plot of Prickly Pear after spraying with 2·5 per cent. solution of Arsenic Acid (half a gallon of solution per approximate cwt. of pear).

(a) *Arsenic Acid*, As_2O_5 .—Dr. Jean White's conclusion was as follows :—For poisoning prickly pear by either injection or spray methods there is no doubt that arsenic acid is superior to all other chemical specifics. Apart from the fact that the results furnished by it, as an efficient pear-destroyer, are very much in advance of those furnished by any other specific tried here (at Dulacca), it possesses three valuable characteristics—

1. It is soluble in both hot and cold water.
2. While every care must be exercised in the handling of this specific, it is far less likely to prove injurious to an operator than many of the other poisons employed as pear-destroyers.
3. Under normal conditions, it is comparatively cheap.

As the result of the many thousands of experiments undertaken at the Dulacca Experiment Station, the following instructions as to the method of using arsenic acid were formulated.

1. *For the injection of undiluted specific.*—2·5 grams (38 grains or $\frac{1}{11}$ oz.) of arsenic acid should be injected per approximate cwt. of pear. The poison should be injected into the second segment from the top of the branch of pear, and about three segments should be injected in each plant. Choose, as nearly as possible, the bright part of a day in January or February, about 24 hours to four days after a fall of rain.
2. *For the injection of diluted specific.*—About 12·5 grams ($\frac{1}{2}$ oz.) of a 20 per cent. solution of arsenic acid should be injected per approximate cwt. of pear. Proceed in the same way, and choose similar climatic conditions as were specified for undiluted specifics.
3. *For the spraying of solution.*—A 2·5 per cent. solution of arsenic acid in water should be sprayed over all parts of the plant or clump. Half a gallon of solution should be allowed per approximate cwt. of pear. The spray should be applied during the bright part of a day in January, February or early in March, as soon as convenient after a fall of rain.
4. *For the spraying of undiluted liquid specific, or of strong solution of the specific, by means of the atomizer spray.*—A 25 per cent. solution of arsenic acid should be used, of which about 30 grams. (1 oz.) should be allowed per approximate cwt. of pear. Choose the bright part of a day in January, February or the early part of March, as soon as possible after a fall of rain, for the application of the specific.

Arsenic acid is not manufactured in Australia, and it is doubtful whether its local manufacture could be profitably undertaken unless the demand became very large. The pre-war price of this acid in England was about £24 to £25 a ton, or say £33 landed in Australia; this works out at about 3½d. per lb. Since Dr. White's researches indicated its value as a prickly pear destroyer, however, it has been practically unprocurable in Australia, owing to the fact that German supplies were cut off and English chemical manufacturers were engaged on war work. Consequently, up to the present this specific has not been used to any extent for poisoning pear.

It is understood that the Government of Queensland intends to open up an arsenic mine and manufacture arsenic acid on purpose to supply occupiers of prickly pear lands with this chemical.

(b) *Arsenious chloride*, AsCl_3 .—The value of this chemical in destroying prickly pear was discovered by Mr. O. C. Roberts, of Cactus Estates Limited. During recent years arsenious chloride has been manufactured by this company in Melbourne, and has been widely used in Queensland and New South Wales for destroying pear.

For poisoning scattered clumps of pear amongst which it is possible for an operator to move about, the arsenious chloride is sprayed from an atomiser. In the case of dense pear which is impenetrable, the arsenious chloride is vaporized and carried over the pear by the wind. For this operation a machine was invented by the Cactus Estates Company, consisting of an upper trough in which the poison is placed, and a fire-box beneath in which a wood-fire is lighted. The whole machine is on wheels. When the arsenious chloride boils, the vapour passes off to the leeward side of the machine, the best results being obtained when there is a gentle, steady breeze.

The great advantage of arsenious chloride is that it is a liquid, and water is therefore not required in connexion with its use. Since in most prickly pear areas water is a scarce and valuable commodity, this is important. The ease with which the liquid vaporises makes it readily available for gassing, in contradistinction to other compounds of arsenic.

In the process of spraying, the fact that much of the liquid becomes vaporized is probably a disadvantage. The vapour affects all the plants in the neighbourhood, and in the direction of the wind may affect pear plants up to a quarter of a mile away. The vapour thus produced is however not sufficient to kill the plants other than those which are actually being sprayed, the result being that the plants affected by the gas produce a corky external layer, which makes them more difficult to kill by subsequent spraying.

Another disadvantage of arsenious chloride is its highly poisonous nature and its corrosive effect on the skin. The vapour being colourless may be inhaled inadvertently, and those using it should therefore use every precaution. The precautions desirable in use, and antidotes in case of accidental poisoning, will be found on page 48.

(c) *Arsenious Acid*, As_2O_3 .—This was the first compound of arsenic to be used for pear destruction. It is the substance commonly known as white arsenic, or simply as "arsenic." In practice it is used in solution, commonly with caustic soda, or with caustic soda and common salt. Part or the whole of the arsenious acid is in these circumstances combined with the soda to form arsenite of soda.

In common practice a solution of arsenite of soda is sprayed on the pear-plants, and after an interval, when the younger shoots have died and dropped off, the pear is slashed and a second spraying given. The slashing having opened up the plants, this second spraying usually effects the purpose of killing the plants, or at any rate reduces them to a condition in which, after drying, they can be collected and burnt.

The disadvantages of this method are that a considerable amount of water is required for the preparation of the solution, and that a considerably greater amount of labour is required. The advantages are the cheapness of the specific as compared with arsenious chloride, and the smaller risk in handling it. Comparatively dilute solutions have commonly been used for the purpose, and in the Dulacca experiments the minimum amount of spray used per acre was 320 gallons. Since the cost of carting the considerable amount of water required may be very considerable, or even prohibitive in dry localities, experiments were undertaken in New South Wales to determine the effect of much stronger solutions.* Strong solutions of arsenious oxide and caustic soda were prepared and sprayed on the plants at rates of from 5 to 12 gallons per acre, but apparently the results were not very satisfactory, the older parts of the plants not being killed.

(d) *Summary*.—The following may be said to be the main results of the experiments on poisoning undertaken in Queensland and New South Wales:—

1. The most efficient prickly pear poisons are compounds of arsenic or mixtures containing them.
2. Arsenic acid (As_2O_5) is the most poisonous specific, but is unobtainable in Australia.
3. Arsenious chloride (AsCl_3) is the only specific available where the pear is so dense that it can only be gassed. It is a valuable spray, especially in country where water is difficult to obtain. It requires to be handled and used with considerable caution owing to its poisonous nature.
4. Arsenious acid (As_2O_3), "white arsenic," used in solution together with caustic soda, is not so efficient as the other two compounds. It is however much cheaper than arsenious chloride and is less dangerous to use. On the other hand it involves the use of large quantities of water and two spraying operations.
5. Under present circumstances any method of clearing by the use of chemicals costs from £2 10s. to £4 per acre.

3. Eradication by the Employment of Natural Enemies.

Eradication by mechanical or chemical means, though employed in clearing valuable agricultural or pastoral land, is never likely to afford a complete solution of the national problem facing Australia—the extermination of prickly pear.

Even if all land which could be profitably cleared at £4 per acre were entirely freed from prickly pear, great areas of poor land, scrub country and rocky hillsides would remain covered with pear which would perpetually tend to spread on to the cleared land and would thus remain a constant menace.

The spread of prickly pear is like the invasion of a dangerous enemy, advancing slowly but steadily and gradually taking possession of our continent. At the outset the foe was met with knives and spades, at the present

* Darnell-Smith, G. P., and Ross, H. Spraying Experiments to Destroy Prickly Pear. *Agricultural Gazette of New South Wales*, XXIX, p. 1, Jan., 1918.

time it is usually fought by the employment of poison sprays and gas, whose utilization is due to scientific research. We are, however, not holding our own in the contest; the prickly pear still advances. Is there any further remedy in sight which might tip the scale in our favour?

The answer to this question cannot at the present time be given with certainty, but the outlook is promising, the suggestion being that one or more natural enemies, insects that devour prickly pear or fungi that injure it, should be enlisted on our behalf. This method has already been employed in one case with strikingly successful results.

(a) Destruction of Tree Pear by Cochineal Insects.

The Queensland Government's Travelling Commission ascertained that in India and Ceylon the Tree Pear (*Opuntia monacantha*) had in many localities been almost or quite exterminated by a cochineal insect (*Coccus indicus*, Green). The same species of pear was found in South Africa to be preyed upon by a related insect (*Coccus confusus capensis*), but this did not do so much harm to the host plant. Segments of Tree Pear with colonies of each of these insects were sent to Queensland from Ceylon and South Africa respectively. The insects were bred up at Dulacca, and careful tests were made to ascertain whether they would attack plants other than prickly pear. Not only do they die if placed on other plants, but they could not even be induced to feed on any kind of prickly pear except the Tree Pear.

The amount of havoc created by the cochineal insects on this species of pear is marvellous. Soon after the plant becomes attacked by the cochineals it becomes yellow and sickly, and a few months later the entire plant has rotted away, only skin and fibre being left. Any new shoots which may happen to sprout from some less injured node of the plant are very quickly attacked by the insects, and in their turn perish. Figs. 9 and 10 show views of a clump of Tree Pear growing at Charters Towers into which some cochineal insects (*Coccus indicus*) were thrown in April, 1915, and the remains of the same clump about a year later.

The cochineal insects belong to the family of scale insects (*Coccidæ*) which are notorious for the destruction they cause to plants. The sexes are very different, the male being a minute short-lived insect furnished with a pair of transparent wings, whilst the female is wingless, and when adult settles down on the plant and covers itself with a white, mealy tomentum. This mealy covering, which represents the scale formed by other scale insects, is all that is visible on an infected plant of prickly pear. When the female is full-grown she lays eggs and dies, her body forming a protection for the eggs. Sooner or later these hatch, giving rise to active little larvæ, which are capable of travelling considerable distances before they settle down.

It is stated on good evidence that clumps of pear in the Charters Towers District, over a quarter of a mile from the nearest patch of cochineal-infested plants, have been discovered and attacked by the insects. In less than a year they spread for many miles along the banks of a creek where patches of the pear occurred, and it is evident that in a comparatively short period this species of pear could be practically exterminated from Australia by the widespread distribution of the cochineal insect.

The Tree Pear is, however, not a serious pest, and, as already mentioned, attempts to induce the cochineal insect to attack other species have all failed. There seems room for further experiment in this direction, however; for example, it is possible that a hybrid might be produced between the Pest Pear and the Tree Pear, and that the cochineal insect might be induced to feed on this, and after a time be transferred successfully to the other parent. It is also possible that if the juice of the Tree Pear were injected into a plant of the Pest Pear, the cochineal insect would be prepared to settle down on the latter, and that the amount of fluid injected might then be gradually diminished until the insect was acclimatised on the Pest Pear. Other possible ways of bringing about the required result might easily be suggested, and surely the



Fig. 9.—Clump of Tree Pear (*Opuntia monacantha*) growing at Charters Towers.

Governments concerned are neglecting an obvious duty until they have investigated every possible method which presents a possibility of grappling with Australia's most formidable foe.

(b) Other Natural Enemies of Prickly Pears.

The only natural enemies of prickly pears that have been successfully introduced into Australia hitherto are the two kinds of cochineal insects dealt with in the previous section. The success obtained by their aid in the

eradication of the Tree Pear certainly encourages the idea that the introduction of other enemies might have an equally valuable result in the eradication of other species of pear.

Enemies of plants may be divided into two classes, namely, those which live on a great variety of plants, which may be called omnivorous vegetarians,

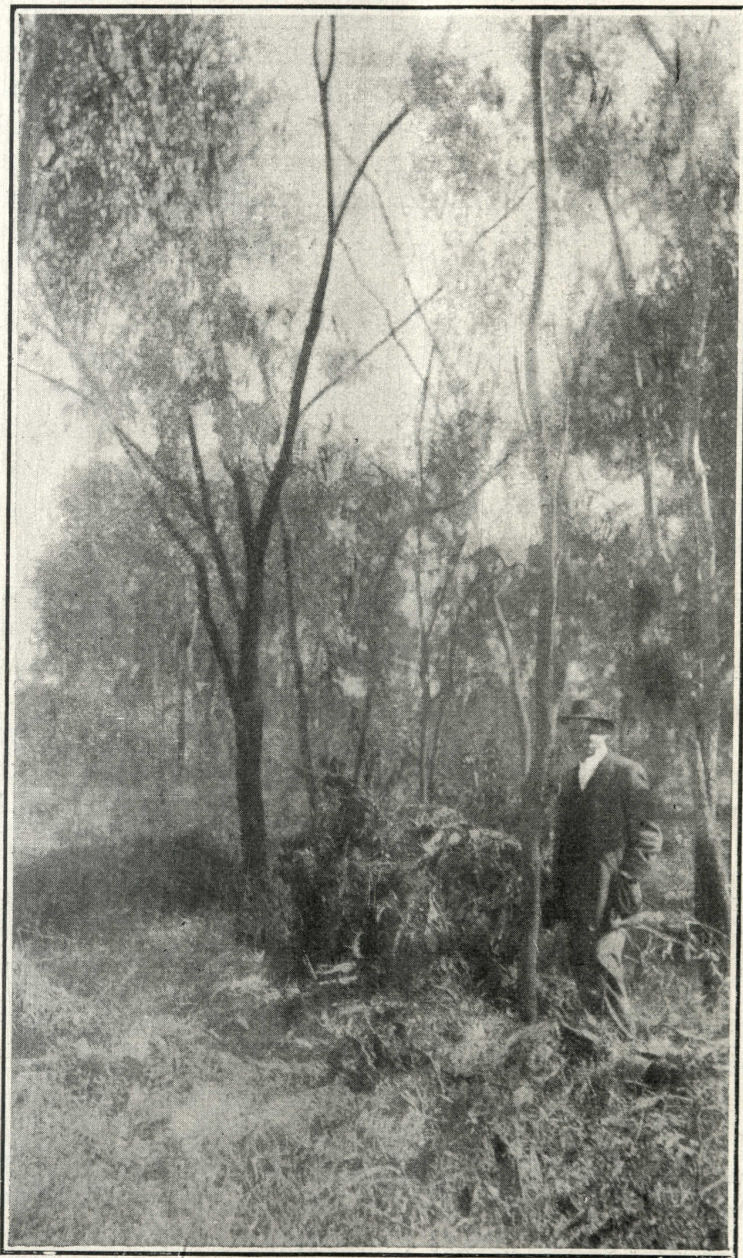


Fig. 10.—Remains of the Clump shown in Fig. 9 a year after the introduction of the Wild Coccineal Insect (*Coccus indicus*).

and those which can only live on a particular species of plant or plants of a single natural family, which may be called restricted vegetarians.

This distinction should be carefully borne in mind when discussing the possibility of utilizing natural enemies for the destruction of vegetable pests. Owing to the fact that many forms of life introduced into Australia have

become widely destructive to a great variety of plants, a strong feeling has grown up adverse to the introduction of any more foreign animals of any kind whatsoever. There is, however, no introduced animal whose destructive habits in Australia could not have been foreseen if careful inquiries had been made beforehand in the countries from which they were brought. The case of the rabbit is often quoted, and many people in Australia appear to believe that the great destructiveness of this pest in Australia is quite peculiar to this continent. Any one familiar with conditions in England knows, however, that in country affording good cover for rabbits it is necessary to use wire netting to protect crops or young plantations just as is the case in Australia. The larger population, the severer winters, and the presence of natural enemies in the form of stoats and weasels are undoubtedly the main or only reasons why rabbits are not such serious pests in England as in Australia.

The natural enemies of prickly pear, like those of other plants, fall into the two categories already mentioned. Owing to its succulence the prickly pear may in some cases form the principal food of certain omnivorous vegetarians in localities where it is abundant, yet there is no question that if the prickly pears were exterminated these forms would continue to thrive on the native vegetation or cultivated crops, hence their introduction would be quite unjustified.

Amongst these omnivorous vegetarians certain rodents, snails, and insects may be mentioned. In the cactus regions of the United States and Mexico there occur several species of "wood-rats" belonging to the genus *Neotoma*, which at times cause great havoc to prickly pear, utilizing it as food to such an extent sometimes as to exterminate it in some areas. However, since they are not restricted in their dietary to prickly pears their introduction to Australia would involve grave risks, and cannot be recommended.

Mr. W. W. Froggatt has observed that the common snail (*Helix aspersa*) is specially fond of prickly pears in Sydney gardens, and therefore recommended that a very large snail (*Achatina fulica*), from Africa, should be introduced into prickly-pear areas.* This suggestion should be strongly opposed on similar grounds, since the snails are omnivorous vegetarians.

Similarly, numerous vegetarian insects feed largely on prickly pear in America, but are known to feed also on other plants. Included amongst these are the fruit-fly (*Ceratitis capitata*), the mealy bugs (*Pseudococcus obscurus*, and *Rhizococcus multispinosus*), the Cuban cactus-scale (*Palæococcus sp.*), the plant-bug (*Stylopidia picta*), the blossom-injuring beetle (*Trichochrous texanus*), the root-boring beetles (*Cactophagus spp.*), the cactus aphid (*A. gossypii*), and the cactus red-spider (*Tetranychus sp.*). In Australia, also, certain native plant-feeding bugs have been observed sucking the juices of prickly pear, and at times causing damage to the plants thereby. These include the Rutherglen bug (*Nysius venitor*), and the coon bug (*Oxycarenus lenticulosus*). The utilization of any of these cactus enemies for the destruction of prickly pear is too dangerous an experiment to be attempted.

* Froggatt, W. W. Insects and Prickly Pear. *Agricultural Gazette of New South Wales*, vol. XXVIII., p. 417, 1917.

Putting aside these omnivorous vegetarians, which may at times destroy prickly pear, there are numerous insects of different groups which are restricted feeders and live only on plants of this order. Those at present known are chiefly those found in the United States, where their habits have been carefully studied by entomologists of repute. In some respects these insects are as



Fig. 11.—A Cactus Longicorn Beetle (*Moneilema crassum*). (From "The Principal Cactus Insects of the U.S.A., Bulletin 113, Bur. Entomol., U.S.D.A., 1912, plate 1. Q'ind. Travelling Commission's Report. Fig. 37.)

peculiar as the cactus plants themselves, and it is clear that the association between insects and plants is very close. Probably in Mexico, Central and South America, many other such insects exist which are at present little known or entirely unknown.

It may be objected that, since these insect enemies of prickly pear do not succeed in exterminating the plants in their native countries, it would be little use to introduce them to Australia. In their native countries, however, it is probable that all of them have to contend with enemies of their own, mainly in the form of other predaceous or parasitic insects. In introducing them to Australia care would have to be taken that their parasites were not introduced at the same time, and if this were successfully accomplished it is difficult to set a limit to the possible benefits that might result from such introductions. Even if natural enemies did not exterminate the prickly pear, if they were able to hold it in check and prevent its alarming increase, other measures could then be adopted for its gradual eradication. At present, whilst considerable areas are being cleared by mechanical means and by poisoning, much larger areas in other districts are all the time being overrun by the pest, so that the foe is always increasing its stranglehold on Australia's land.

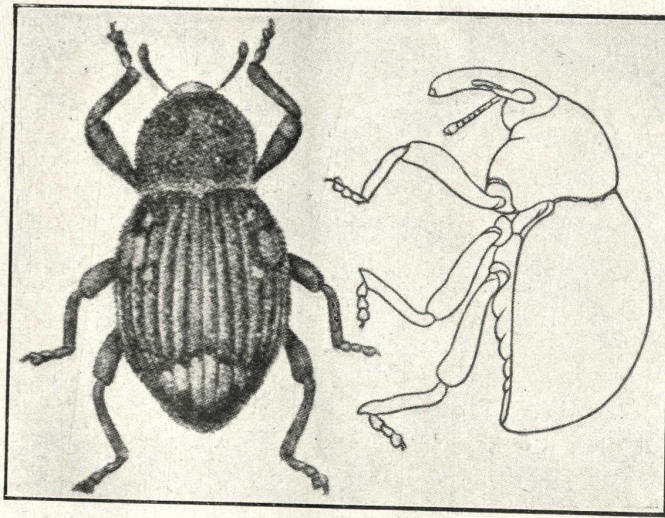


Fig. 12.—One of the Cactus Weevils (*Gerstaeckeria nobilis*). (Reproduced from Bull. 113, Bureau Entomol. U.S.D.A., p. 30, fig. 3, by the Q'land. Travelling Commission. Report. Fig. 40.)

It is not recommended that cactus insects should be introduced indiscriminately. On the contrary, each case should be considered on its merits. Those which are already well known in their native country, and whose records show that they never attack plants other than cactus, should be introduced first, and careful tests made as to whether they show any disposition to attack other plants under Australian conditions before they are liberated in the prickly-pear areas. Other insects would meanwhile be studied in their native lands, and when the evidence was sufficient would be brought to Australia and a similar procedure followed.

As a result of the work of American entomologists and the inquiries made by the Queensland Government's Travelling Commission, the following species were recommended by the Commission for introduction to Australia :—

(1) *Moneilema*.—(Fig. 11.)—Large black wingless long-horned beetles widely distributed in the drier parts of the United States and Mexico. The larvæ of these beetles are large grubs which live in tunnels bored by them in

the stems and joints of prickly pears, whilst the adults feed gregariously on the young segments of the plant. Several species of the genus are known.

(2) *Cænopæus palmeri*.—A large long-horned beetle with similar habits found in Southern California and the adjacent regions.

(3) *Gerstæckeria hubbardi*.—(See Fig. 12.)—A cactus weevil found in Florida, whose larvæ feed within the segments of the prickly pear, producing cavities which facilitate secondary infection by micro-organisms and certain scavenging flies. The destruction caused by this species is commonly associated with that produced by a moth, *Melitara* sp.

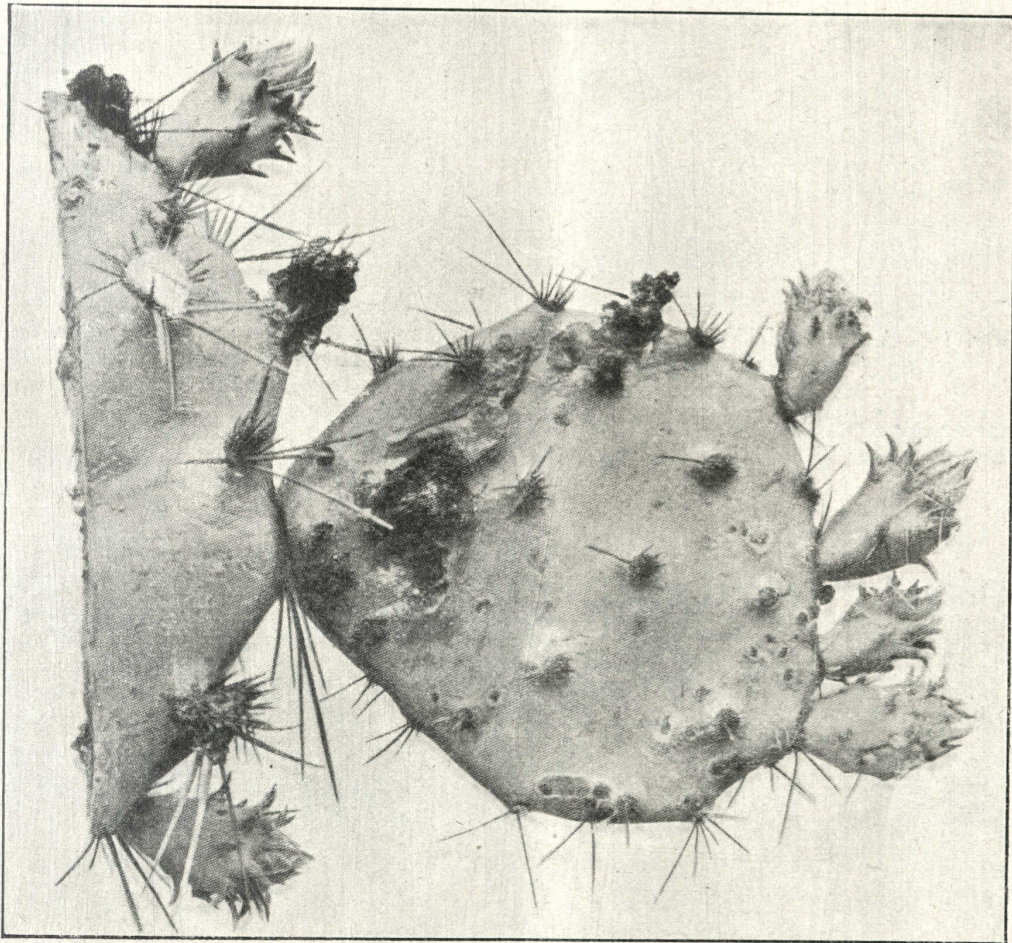


Photo., Bureau of Entomology, Dept. Agriculture, U.S.A.

Fig. 13.—*Opuntia engelmanni*, showing a black exudation from some of the areoles, due to the presence of the larvæ of a cactus weevil, *Gerstæckeria nobilis*. (Q'Ind. Travelling Commission's Report. Fig. 43.)

(4) *Melitara*.—(Fig. 14.)—Cactus moths, belonging to the family *Phycitidæ*, found in the United States, Mexico, and the West Indies. The caterpillars of these insects live within the joints of the prickly pear plant and cause great destruction, partly on account of their eating out the tissues and partly on account of the rapidity with which attacked segments become invaded by secondary organisms, such as bacteria, fungi, and scavenging flies. The death of infected joints, and even plants, is a quite common result.

(5) *Mimorista flavidissimalis*.—A small yellowish or straw-coloured moth belonging to the family *Pyralidæ*, found in Texas, the West Indies, and Brazil. The caterpillars cause a great destruction of young segments of prickly pear.

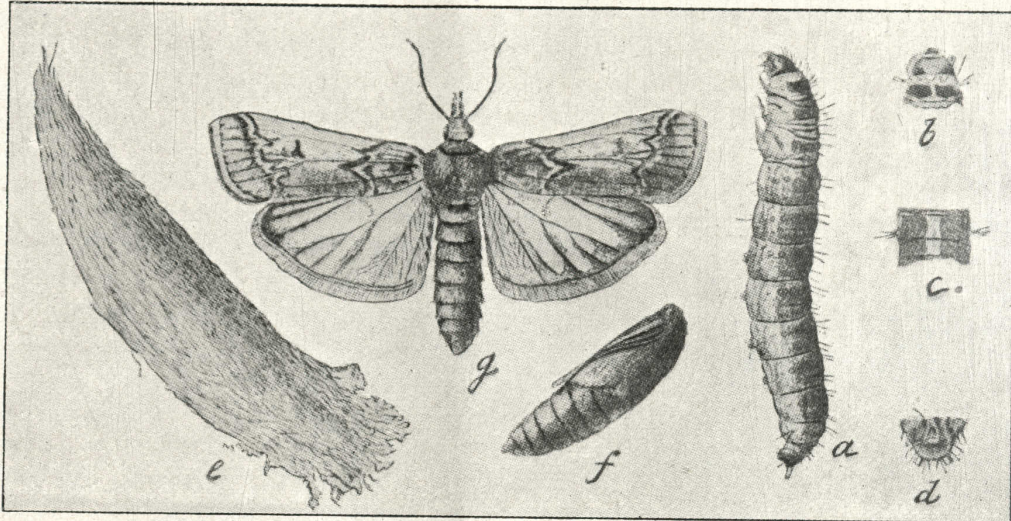


Fig. 14.—A Cactus Moth (*Melitara prodenialis*). *a*, larvæ; *e*, cocoon; *f*, pupa; *g*, moth. (Reproduced by Mr. O. Swezey, H.I.S.P.A., Honolulu, from the original in the Proc. Entomol. Soc., Washington, iii., 1896, p. 132. Report of the Q'land Travelling Commission. Fig. 36.)



Fig. 15.—Segment of an *Opuntia* showing the work of the larvæ of a moth, *Mimorista flavidissimalis*. (Reproduced from "The Principal Cactus Insects of the U.S.A.," Bull. 113, Bur. Entom., U.S.D.A., plate 3, by the Q'land Travelling Commission. Report. Fig. 39.)

(6) *Zophodia cacorum*.—The cactus-borer moth of the Argentine, belonging to the family *Phycitidae*. The larvæ of this moth feed in colonies within the joints of prickly pear plants, to which they are very destructive. When one joint has been eaten out they emerge and penetrate into another. The injury caused by the larvæ themselves is greatly increased by the invasion of micro-organisms and scavenging flies, with the result that the plants are frequently entirely destroyed. Another moth whose larvæ have somewhat similar habits and cause serious damage to prickly pears was met with by the Queensland Commission at Mendoza in the Argentine, and is referred to as the Mendoza Moth Borer, as its scientific name was not ascertained.

Larvæ of the former species, *Zophodia*, were brought by the members of the Commission to Queensland, and it was found that they would feed on the Pest pear. Probably owing to lack of knowledge of their habits the attempt to rear them to maturity and establish them in Queensland was not successful.

(7) *Chelinidea*.—Cactus bugs, belonging to the family *Coreidæ*, usually nocturnal and gregarious in habits. They feed on the joints of prickly pear, sucking the juices. Each spot where feeding has taken place becomes discoloured, and the discoloured areas gradually enlarge and become confluent, the joint ultimately rotting and dropping off the plant.

(8) *Narnia*.—Another genus of cactus bugs of the family *Coreidæ*, living exclusively on cactus, but confining their attacks to the fruits, which are often destroyed thereby.

(9) *Coccus*.—(Fig. 16.)—The wild cochineal insects, of which two species (*C. indicus* and *C. confusus capensis*) have already been introduced, and, as has been shown above, have proved very effective in destroying *Opuntia monacantha*. The different species and varieties of cochineal insects appear to be usually confined to particular species of prickly pear, and in America the amount of destruction they cause does not appear to be very considerable. They are, however, in their native country largely preyed upon and parasitized by other insects, and where they have been introduced into countries where these enemies are absent have been proved to be efficient in destroying particular species of prickly pear. Careful study of the cochineal insects of America might possibly result in the discovery of a species of cochineal insect as destructive to *Opuntia inermis* as *Coccus indicus* is to *O. monacantha*.

(10) *Itonida opuntiae*.—A cactus gall-midge found in the United States, whose larvæ produce galls under the areoles. Under hot-house conditions these galls not infrequently become the seat of secondary infections, which lead to the destruction of the attacked prickly pear plant. It is not known whether a similar result ever occurs with plants in the wild state.

(11) *Asphondylia opuntiae*.—Another kind of cactus gall-midge found in the United States. The larvæ of this species, however, almost always live in the fruit, and their presence causes this to develop into a joint instead of developing seeds. Thus reproduction by seed, in localities where these midges are plentiful, is almost entirely prevented, and an important method by which prickly pears spread is eliminated.

(c) Diseases of Prickly Pears.

Prickly pears do not, as a rule, suffer very seriously from diseases. Occasionally malformations are met with, apparently due to unfavorable environment, and a certain number of fungi attack the plant, in some cases causing considerable amount of destruction.

A case of this kind occurred at Harrington Inlet, on the Manning River, New South Wales, in 1918, where the common Pest pear was attacked by a species of fungus belonging to the genus *Fusarium*.* A diseased clump of pear was noticed by Mr. L. A. McDougall, and portions from this clump were thrown into other clumps of prickly pear at a considerable distance. Eight months later the clump in which the disease had been first noted was almost

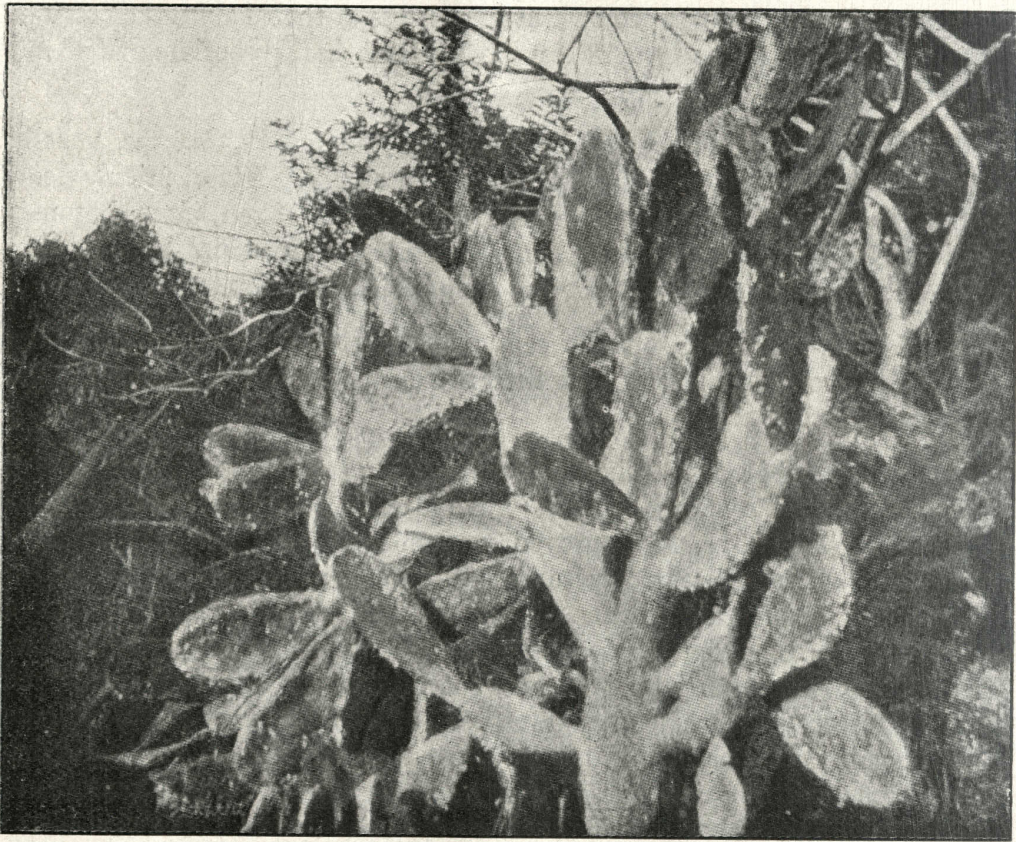


Fig. 16.—Wild Cochineal (*Coccus confusus newsteadi*) on *Nopalea cochinifera*, Antigua, West Indies. (From Report of the Q'nd. Prickly Pear Travelling Commission. Fig. 45.)

dead, the young segments being entirely rotten, and the older parts a sickly yellow colour. The clumps into which portions of the original plant had been thrown were also infected, and the young shoots becoming rotten.

In the United States the "anthracnose," "shot hole," or "black rot" disease of prickly pears, caused by a fungus, *Clæosporium lunatum*, sometimes does considerable damage. Ordinarily this organism has but little effect on the plant, but under conditions such as obtain on warm moist days

* Darnell-Smith, G. P., and Ross, H. A Fungus Disease of Prickly Pear. *Agricultural Gazette of New South Wales*, vol. XXIX., p. 440, June, 1918.

it causes a considerable and rapid destruction of young segments, while older joints previously infected may also succumb to the "black rot" conditions set up. The Travelling Commission recommended that this fungus should be introduced to Australia, and attempted to do so by bringing cultures with them. These, however, proved to be dead when tested at Dulacca.

In the Argentine prickly pears suffer from a very serious disease, the "white rot," caused by a fungus, *Sclerotium* (or *Sclerotinia*) *opuntiarum*, which brings about the destruction of the joints and stems of various species. Further study of this disease, especially in the direction of ascertaining whether it attacks plants other than prickly pears, is desirable, as too little is known about it to make it safe to introduce it into Australia.

(d) Destruction of Prickly Pear by Overgrowth.

It has been suggested that the introduction to Australia of a certain fodder grass from Brazil might be of service in destroying prickly pear, as on account of its very rapid growth it would probably choke the pear plants.

A statement was also made that prickly pear would not grow in the neighbourhood of a local plant known in Queensland as "Coughing Bush," but the statement was not supported by the evidence, since pear plants were found growing in a healthy state amongst these bushes.

In parts of South America a rapidly-growing climbing leguminous plant is used for destroying prickly pear. Seeds of the plant are sown round the clumps of pear, and when the plants have covered the pear with a network of twining branches, the stems are cut and the plants allowed to dry. Subsequently the whole mass is set alight, and the prickly pear thus badly scorched. A second repetition of the same process may altogether destroy the pear.

There is a serious danger that any plant vigorous enough to choke prickly pear might become a worse pest than the pear itself, hence this method of destruction cannot be recommended.

D.—CONCLUSION: REPORT AND RECOMMENDATIONS OF THE EXECUTIVE COMMITTEE OF THE ADVISORY COUNCIL.

The following report and recommendations on the control and eradication of the prickly pear were adopted by the Executive Committee of the Commonwealth Advisory Council of Science and Industry in December, 1916 :—

1. The eradication of the prickly pear, being one of the problems mentioned in the initial report on the constitution of the proposed Institute of Science and Industry as specially urgent, has received close attention from the executive since the commencement of its activities.
2. The Executive Committee has fully informed itself of the research work on the problem already carried out in Queensland by the State Government's Board of Advice on Prickly Pear Destruction. The executive has also interviewed members of the State Governments of New South Wales and Queensland, and ascertained the attitude of these Governments towards the problem.

3. Some 20,000,000 acres of land in Queensland and 2,750,000 acres in New South Wales are at present infested with prickly pear, and it is estimated that the pest is spreading in Queensland at the rate of 1,000,000 acres a year. Prickly pears have also established themselves in various localities in Victoria, South Australia, and Western Australia, but are not at present serious pests in these three States. Eleven species of prickly pear have become naturalized in Australia, but *Opuntia inermis* is the species whose spread has been so serious and which occupies the great bulk of the pear-infested land.

4. The only practicable means of dealing with the plague appear to be :—

(1) Chemical (by poisoning).

(2) Biological (by introducing insects or fungi which act as a natural check on its growth).

Various proposals have been made to deal with the prickly pear by mechanical means by cutting or rolling it down. These have not, however, been found practicable. Other proposals have been made to dispose of the pear by utilizing it for certain purposes. But even if a profitable means of utilization were discovered, it would be quite impracticable to establish in Australia factories on a sufficiently large scale to deal with any substantial proportion of the pear. The most likely use for prickly pear is for fodder, but all the cattle in Australia could not keep pace with the rate at which the pear is extending in Queensland alone. It is necessary first to find some means of controlling and eradicating the pest. Any experiments made with a view to the discovery of some practicable use for the pear should not be conducted in the belief that they can lead to its control.

5. An elaborate series of investigations on the effect of all known plant poisons on the prickly pear was carried out by Dr. Jean White, for the Queensland Government, at Dulacca. These investigations have shown that the cheapest and most efficient means of destroying prickly pear are by the injection or spraying of the plants with arsenic acid or by gassing it with the fumes of arsenic trichloride. The quantities of these substances required and the seasons when they can be used to most advantage have also been ascertained. The Dulacca Experiment Station was closed on 30th June, 1916, and the Queensland Government have offered to hand it over to the Commonwealth for the use of the Advisory Council in any further researches it may undertake.

6. Chemical poisoning will only pay on agricultural land, which is but a small proportion of the infested area. The pear on grazing land of low value can only be kept in check by biological means, and meanwhile these lands act as sources from which the land already cleared is in perpetual danger of re-infestation.

7. The first part of the necessary biological investigation was carried out by a Travelling Commission, consisting of Dr. T. H. Johnston and Mr. H. Tryon, appointed by the Queensland Government. These gentlemen spent nearly two years visiting almost all the countries of the world where prickly pears are found, either native or acclimatised, and investigating the natural enemies of the plants.

8. The Commission introduced a species of cochineal insect which feeds on *Opuntia monacantha*, and after careful tests at Dulacca had shown that it

would not attack cereals or fruits of any kind, it was liberated at Bowen and Charters Towers, with the result that *Opuntia monacantha* in those localities has been largely destroyed. Unfortunately, this insect will not feed on any other species of prickly pear.

9. The Commission prepared a list of a number of other insects which live entirely on prickly pear in America, and are not known to feed on any other type of vegetation, and which they recommend should be introduced to Australia with proper safeguards. They also made tentative arrangements with the United States Bureau of Entomology for the collection and despatch of these insects. They further recommend that two fungi which cause diseases of prickly pear in South America should be introduced and investigated. These suggestions have not been acted upon up to the present.

10. As the result of an interview which the Committee had with members of the Government of New South Wales, the Minister for Agriculture announced that £2,000 had been placed on the Estimates to be at the disposal of the Advisory Council for research work on the prickly-pear problem, provided that the money is spent in the State. He also indicated that this sum would be continued for five years. The Committee also interviewed members of the Queensland Government, and it is practically certain that the Government of that State will be willing to contribute the same amount as New South Wales (£2,000).

RECOMMENDATIONS.

The Executive Committee therefore recommends—

- (a) That investigations should be carried out as to the suitability of insects and fungi known to be inimical to prickly pear for acclimatisation in Australia, as to the method of action of such insects or fungi on the pear, and as to such other matters as may arise in connexion with any biological or chemical researches found necessary.
- (b) That the work should be placed under the authority of a biological expert, who shall be responsible to the Executive Committee of the Advisory Council of Science and Industry, and who should receive a salary of £1,200 per annum.
- (c) That three laboratories, comprising one central laboratory and two subsidiary laboratories, should be established and maintained in Queensland and New South Wales.
- (d) That the central laboratory should be established at Brisbane, where the insects would be received immediately they reached Australia, and where the staff would have access to literature and facilities for the use for special investigations of University and Government laboratories.
- (e) That the two subsidiary laboratories should be established in country infected with prickly pear. One of these should be in New South Wales, whilst, for the other, the Queensland Government's offer of the Dulacca Experiment Station should be accepted. These stations would carry out the work of breeding and testing the introduced insects, and should be in charge of thoroughly qualified entomologists, at salaries of £750 per annum.

- (f) That field laboratories should be established, at such places and at such times as may be deemed necessary by the biologist in charge, for the purpose of introducing such insects as are found suitable into particular areas, or for other special purposes.
- (g) That the sum of £8,000 per annum for a period of five years should be made available for this work, of which sum £4,000 should be contributed by the Commonwealth Government and £2,000 each by the Governments of New South Wales and Queensland.

It is regarded as important that provision should be made that such amount as may remain unexpended at the expiration of any one year should not lapse, but should be carried forward to the next year. Owing to the nature of the inquiry, the fact that the insects will have to be bred to some extent in America and the dependence of the insects on seasonal factors, it seems probable that part of the sum allotted for this purpose in the first year will remain unexpended, and that correspondingly this item will be increased in the second year.

NOTE.—The Commonwealth Government approved of the scheme outlined above, and forwarded copies of it to the New South Wales and Queensland Governments, asking for their assent and co-operation. The Queensland Government has agreed to co-operate, and to provide a sum of £2,000 per annum for five years. The New South Wales Government suggested certain modifications, which have received the careful consideration of the Executive Committee of the Institute of Science and Industry. It is hoped that an arrangement will shortly be arrived at which will meet the views of the New South Wales Government.

APPENDIX I.

Sources of Information and Bibliography.

In the compilation of this bulletin the author has made frequent use of the following publications :—

The Prickly Pears of Interest to Australians, by J. H. Maiden, F.R.S. A series of articles published from time to time in the *Agricultural Gazette* of New South Wales, of which a complete list appears in the footnote on page 9 of the bulletin.

Reports of the Prickly Pear Experimental Station, Dulacca, by Dr. Jean White-Haney. Reprinted from the Annual Reports of the Queensland Department of Lands for the Years 1912, 1913, 1914, and 1915.

Report of the Prickly Pear Travelling Commission, by Dr. T. Harvey Johnston and H. Tryon. Queensland Parliamentary Paper C.A. 91, 1914.

The latter report contains a vast amount of valuable information collected all over the world, but, owing to the geographical arrangement of the information and the lack of an index, it is most difficult to find in it all the information bearing on any particular point. The writer is indebted to Mr. J. Brownlie Henderson, F.I.C., Chairman of the Queensland Government's Board of Advice on Prickly Pear, for the loan of his own copy of the report in which he has inserted a partial index, which greatly facilitates reference.

The Report of the Travelling Commission contains a comprehensive bibliography of publications on prickly pear up to the date of its publication in 1914.

It may prove useful to give here a list of the papers published since that date which have come under the notice of the writer during the work of compiling this bulletin. Doubtless the list is far from complete :—

1914. Maiden, J. H. The Prickly Pears of Interest to Australians, XII. Agr. Gaz. of N.S.W., 25, 1914, p. 883.
1915. White-Haney, Jean. Report of the Officer in Charge of the Prickly Pear Experimental Station, Dulacca. Appendix 4. Ann. Rept. Dept. Public Lands, Qld., for the year 1914 (1915).
Maiden, J. H. The Prickly Pears of Interest to Australians, XIII. Agr. Gaz. of N.S.W., 26, 1915, p. 489.
1916. White-Haney, Jean. Report of the Officer in Charge of the Prickly Pear Experimental Station, Dulacca. Appendix 4. Ann. Rept. Dept. Public Lands, Qld., for the year 1915 (1916).
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In February, 1918, the writer paid a visit to Scone, New South Wales, a district which is specially interesting as being the centre from which prickly pear first spread, and in which the oldest prickly pear plants in Australia are found. For assistance in connexion with this visit, and opportunities to see something of the actual campaign against the pest, he is greatly indebted to Mr. H. L. White, of Belltrees, Mr. G. Valder, Under Secretary for Agriculture, New South Wales, and Mr. O. Brooks, Inspector of Stock, Scone.

To Mr. J. B. Henderson and Mr. H. Temple Clerk, of Brisbane, the writer is indebted for information verbally supplied, as well as for the loan of photographs to illustrate the bulletin.

Mr. E. G. Scriven, Under-Secretary, Department of Agriculture and Stock, Queensland, has kindly supplied information relating to the introduction and spread of prickly pear in that State.

APPENDIX II.**Notice to Users of Arsenious Chloride as to Precautions Desirable in Handling, and the Best Remedies in Case of Accidental Poisoning.**

The following notice has been prepared jointly by the Chemical Committee of the Institute and the Cactus Estates Ltd., manufacturers of arsenious chloride :—

Arsenious Chloride is Poisonous.

If it should be inadvertently swallowed, the mouth and throat should be promptly gargled with soapy water, and an emetic consisting of soap dissolved in warm water should be promptly administered.

The Fumes are Irritating and Poisonous.

If the fumes should be inadvertently inhaled sufficiently to cause irritation of the nose, throat, or lungs, the mouth and throat should be promptly gargled with soapy water ; and in case of pronounced irritation, weak ammonia fumes such as the fumes from ammoniacal smelling salts should be inhaled through the mouth and nose.

It Corrodes the Skin.

If spilt on the skin, the part affected should be promptly rinsed with water, or, preferably, soapy water.

In cases of continued irritation, the part affected should be washed with soap and water until the irritation ceases.

Precautions.

1. When spraying or otherwise using the arsenious chloride keep to the windward of the fumes. A moist (not wet) handkerchief used as a respirator will tend to prevent fume dangers.
2. When handling the arsenious chloride carefully avoid splashing or spilling about. Promptly wash all spillings and splashings away with water.
3. When using arsenious chloride, a vessel containing water, or, preferably, soapy water, should be kept handy for rinsing purposes.
4. All vessels used in dealing with arsenious chloride should be carefully washed clean with water or soapy water immediately after being used.
5. Do not under any circumstances keep or leave arsenious chloride in vessels not clearly labelled "Poison."
6. Users of arsenious chloride should keep on hand ammoniacal smelling salts.

The following

PUBLICATIONS

will be supplied on application
to the Secretary

Free of charge—

Report of the Executive Committee of the Commonwealth Advisory Council of Science and Industry for the year ended 30th June, 1918.

Resolutions passed by the Advisory Council, July, 1917, together with Report and Recommendations on the Organization and Work of the Proposed Permanent Institute of Science and Industry.

Recent Developments in the Organization of National Industrial Research Institutions, by Gerald Lightfoot, M.A.

On pre-payment of the amount indicated—

Atlas of Contour and Rainfall Maps of Australia. 1/6

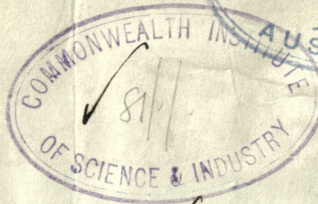
The following
BULLETINS

will be supplied post free on application
to the Secretary

1. The Cattle Tick in Australia
(*Out of print—See No. 13*)
 2. Worm Nodules in Cattle
 3. The Alunite Deposits of Australia and
their Utilization
 4. The Factors Influencing Gold Deposition
in the Bendigo Goldfield. Part I.
(*Out of print*)
 5. Wheat-Storage Problems (Damaged Grain and
Insect Pests)
 6. Power Alcohol: Proposals for its Produc-
tion and Utilization in Australia
 7. Agricultural Research in Australia
(The individual papers contained in this Bulletin
can also be supplied separately.)
 8. The Factors Influencing Gold Deposition
in the Bendigo Goldfield. Part II.
 9. The Manufacture and Uses of Ferro-alloys
and Alloy Steels
 10. Substitutes for Tin-plate Containers
 11. Paper-Pulp: Possibilities of its Manu-
facture in Australia
 12. The Prickly Pear in Australia
-

To appear shortly—

13. The Cattle Tick Pest in Australia
14. An Investigation of the Marine Fibre of
Posidonia Australis



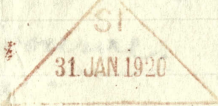
who are seeking employment could be employed clearing this huge tract of land.

Should you think anything of this proposition, I shall be glad if you will communicate with me your views on the matter

Thanking you in anticipation
I am

Yours faithfully

J. H. Green.



The Acting Comptroller-General,
Department of Trade and Customs.

Referred for favour of advice.

M. L. Shepherd

Secretary,
Prime Minister's Department,
21.1.20.

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JAN 22 REC

The Secretary,
INSTITUTE OF SCIENCE & INDUSTRY.

For favor of advice.

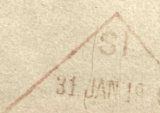
Ranch Oakley

Acting Comptroller-General.

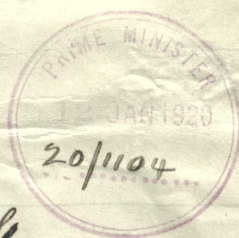
21/1/1920.

ackd.
21.1.20

Success, I would be prepared to sell the 'recipe' straight out to the Government, or work the specific for the Government, when all the returned soldiers



C/o A. J. Hughes.
121 Regent St.
Sydney.



— Jan. 9th 1920.

W. M. Hughes. P.C.

Prime Minister. Commonwealth Government.
Melbourne.

Dear Sir,

Now that various schemes have been, rare being placed before the Government, I notice nothing is being done for the eradication of the Prickly Pear. Having been interested in this branch, not only in Australia, but in other Countries, I claim to have the specific to eradicate this pest, which is not injurious to handle, cheap to prepare & does not interfere with the soil. Seeing we have between fifty sixty million acres of the best land covered with this pest, with an annual increase of at least two millions, what value can be placed upon any cheap specific which will do its work thoroughly.

I am prepared to submit to test, my specific & willing abide by the result. In the event of success, I would be prepared to sell the recipe straight out to the Government, or work the specific for the Government, when all the returned soldiers

Ackd.
21.1.20





7320/1288
1919/15096

[Handwritten signature]

F.

20/1104/2

Melbourne, 6th February, 1920.

Dear Sir,

With reference to your letter of the 9th January, relative to the question of the eradication of the prickly pear, I am directed to inform you that if you are willing to disclose, in confidence if desired, complete information regarding your specific, its cost, methods of preparation and use, together with particulars of any experiments carried out, the matter will receive full consideration.

Yours faithfully,

J.H. Green Esq.,
C/o A.J. Hughes Esq.,
121 Regent St.,
SYDNEY.

Secretary.

[Handwritten checkmark]

The Acting Comptroller-General,
Department of Trade & Customs.

Referred in connection with your minute of the 5th February, hereunder.

Seen

M. L. Shepherd
Secretary, *per [initials]*
Prime Minister's Dept.
6/2/20.

9/2/20 *RO per [initials]*

Please write [illegible]

Records

Please mark to PMS [initials] 12/2/20