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DEPARTMENT OF FISHERIES AND FAUNA
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REPORT ON MARRON IN FARM DAMS

(Cherax tenuimanus)

By N.M. Morrissy

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C O N T E N T S

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I INTRODUCTION

A programme of selling marron (Cherax tenuimanus) to country dwellers for stocking farm dams, has been carried out by the Pemberton Trout Board for the past few years with considerable financial gain. In this case permission to sell the marron was granted by the Department of Fisheries and Fauna so as to encourage the provision of stocks of this large, freshwater crustacean for farmers in the dryer inland areas of the Southwest which are remote from sources of fresh fish and from natural stocks of marron.

The marron, however, have been sold indiscriminately, upon request, without any advice as to the degree of suitability for them of the recipient dams. There has been no appraisal of the general success of the scheme or advice given as to how best to manage stocks of marron which have been successfully established.

This study was started by the Department because apprehension has arisen from the knowledge that a similar, earlier scheme with trout faltered after widespread sales. The latter occurred because the scheme was based on a secondhand knowledge that trout had been very successful in a few dams in the dryer areas of the Southwest where the scheme was mainly directed (as is the marron scheme). These few dams were not typical of the dams in these areas and the majority of dams there are not suitable for trout.

This study then seeks to determine the degree of success of the marron scheme over the past few years, the characteristics of farm dams where marron may be well-established, the levels of abundance which may be expected where marron are established and the methods by which the stocks of marron may be best utilized and maintained.

Despatch of marron from Pemberton:

Marron are sold from Pemberton each year during the months January to June. Stocks are captured by hatchery staff in nearby streams during January to April.

The marron are sold at present for \$20 per 50. Earlier an attempt was made to send equal numbers of males and females but the sex ratio of catches from the streams in the earlier months would bias the sample towards males. The marron are sent in oxygenated water contained in sealed plastic bags protected by a carton. Generally marron of sizes 2½ to

4 cms (orbit) carapace length are used. In their natural habitat 50% of 2+ female marron over 3 cms in length breed each year. Development of eggs starts one year before spawning (October). Because the marron are sent by rail, places very distant are given the smaller marron so that they may have more chance of surviving the trip of at least one day in the container.

Types of dams on farms:

There are three main types of surface water storages which are loosely called dams. The only true dam is a structure built across a watercourse to hold back the flow of water. These farm dams are commonly called gully dams. They are only common in the wetter, cooler region of the coastal ranges in the South-west. As might be expected introductions of both marron and trout do extremely well in these clear water dams which are within the limits of the wild distribution of these animals.

Another type of farm dam is the Turkey-nest or ring tank dam. These consist of a completely enclosed earth embankment which is usually filled by pumping from bores. They are built on fairly flat ground in the dryer areas. Their large capacity, compared with the amount of soil moved, is however, obtained by holding a large area of water at a comparatively shallow depth. For this reason they have limited value for Western Australian conditions - a long dry summer and high evaporation.

This study is concerned with the excavated earth tank or dam, the third type. This dam is usually built on an area of sloping ground, for runoff catchment, where there is clay ground to a sufficient depth and no rocks - to prevent leakage, and above any salt-water table. Most of the water is stored below the original ground level. The excavated soil is placed in banks below and on either side of the excavation to give additional storage above ground level. To prevent loss of this above-ground storage by leakage any overburden of topsoil or porous soil above the clay is removed from the site before excavation. A minimum depth of 12' of water stored is required to allow for evaporation during the long dry summer. This usually means a dam of 2,000 cubic yards (volume of excavated soil) or more. This still allows for evaporation in one summer only. (Watson and Grasby. "Planning new farm dams - excavated earth tanks". Bulletin No.3596, W.A. Dept. of Agriculture).

This type of dam is very common in the South-west region. Trout and marron do very well in these dams in the ranges -

where the water is clear due to the heavy pasture growth - algal blooms and emergent aquatic plants occur, and there are abundant subaquatic invertebrates in the usual food chains. Nearly all dams in the dryer flatter areas of sheep-grazing and wheat growing to the east of the coastal ranges are of this excavated earth type. This study is directed to these dams, which have turbid water in these more easterly areas.

Description of the study area:

(From "Climatic Survey. Region 11. Great Southern, W.A.- Commonwealth Bureau of Meteorology).

The "Great Southern" region extends roughly 170 miles north-south and 220 miles east-west. It lies mainly between 32 and 34 degrees south latitude and between 116 and 120 degrees east longitude.

In elevation it is mainly between 1,000 and 1,500 feet above sea level, the highest part being in the north-east where there is a small area above 1,500 feet.

Most of the region consists of well established wheat and sheep farms, though settlement is sparse towards the east where the Rabbit Proof Fence coincides with the present margin of the agricultural area. There is some orcharding and dairying in the South-western corner.

The western and southern borders of the area are mostly within 50 miles of the coast and this causes many climatic factors to show a Southwest-Northeast variation.

Rainfall is over 45 inches near part of the western border and tapers off to 12 inches in the northeast; most of this rain falls in the winter (May to October).

In summer the mean maximum air temperature ranges from 81^{o} in the southwest to 93^{o}F on the northern boundary.

In the Southwest the growing season of plants (length 7 months) opens in early April, and in the Northeast in early May (length 4 months).

II MATERIALS AND METHODS

To determine the influence of summer air temperatures and annual rainfall on the suitability of dams for marron, use was made of the climatic gradient in a north-east direction from Pemberton (Table I). There is a close positive correlation of maximum air temperature, and an almost exponential decrease of rainfalls with increasing distance from Pemberton.

The surveying and sampling of dams was confined as closely as practicable to places spaced along this general transect. This strategy also reduced the amount of travelling on field trips.

Two groups of dams were studied.

(a) Dams chosen from sale of marron records kept at Pemberton ("sales" dams).

During the first year of the investigation (1968) the period February-March was selected for field trips. Records of sales of marron from Pemberton for the period January-June 1967 were the earliest complete set available. These records were used for the study. If the dams involved were suitable for marron the introduced stock should have bred once before the first field trip.

There were 121 records of sales; data available were:- the date of sale, recipient's name and address, and the number of marron sold. Most of these sales were made during the summer and early autumn of 1967. Usually only 1 batch of 50 marron was sold, occasionally 2 (100 marron) but rarely 3 batches to one person. It seems that 50 marron had been judged as the minimum number of marron necessary for a successful establishment of marron in a dam.

The distribution of these sales is shown in Fig. 1 as a number of sales in 50 by 50 mile blocks of the South-west. About ⅓ of the sales occurred in the blocks 2D, 3D, and 4D of the Great Southern District. Only 16% of sales were made to areas where marron occur naturally in streams.

From these sales records, places were selected which occurred broadly in a north-east direction from Pemberton. Further selection was made on the basis of only 50 marron being sold, and on a confirmation of the locality by finding that the surname, at least, of the purchaser was mentioned in the telephone book at or near the locality (many country people use the nearest town as a postal address). This selection left 20 sales which are individually located in Fig. 1.

During a one-week field trip in February 1968 all but one of these "sales" dams were located. A brief time was spent surveying each dam (Table 2) where the marron had been placed and an attempt was made with a long handled scoop-net (⅜" nylon mesh) to establish whether 0+ marron were present. The likely co-operation of the owner of the dam, for future sampling, was also noted.

On the basis of this trip 5 of the dams were chosen for sampling the following month, March, to determine the fate of the introduced marron in terms of survival and growth. The localities of these dams are also shown in Fig. 1.

The same 5 dams were resampled in March 1969.

(b) Dams chosen from a public response to an appeal for the localities of farm dams where marron were successfully established in the opinion of the farmer. ("successful" dams).

During May 1968 a release was made by the Department's Extension Service to Press, Radio, T.V. and Country News media, as follows:

"Marron in farm dams.

The Department of Fisheries and Fauna is anxious to contact farmers of the Southwest who have had success in breeding marron in their farm dams ..... Prior to 1967 many farmers obtained young stocks from the Pemberton Trout Board and it is this group in which the Departmental research officers are most interested. Farmers who have had success in cultivating marron are asked to forward their name and address to .... The area from which the information is sought comprises all of the Southwest of the State from approximately 100 miles north of Perth to east of Merredin and south to Esperance."

From this appeal 21 credible replies were received and also further possible localities near Narembeen were heard of from an informant there. The localities of these "successful" dams are also shown in Fig. 1. Most of these dams occurred in the southern part of the study region.

During a 1½ week field trip in March 1969, 7 of the dams were investigated in detail.

Surveying and sampling of the dams.

(a) Characteristics of the dams.

The general information collected at each place is shown on a sample of the record sheet that was used in the field. As well, black and white photographs were taken. A Beckman pocket pH meter was used to measure pH in situ. During the March 1969 trip a "Thermophil" electronic thermometer, with the thermistor on a 20' lead was used from an inflatable rubber dinghy to find the water temperature at various depths in some dams. These temperature measurements were only made on the two hot days of the trip and at mid-afternoon when maximum water temperatures may be expected.

Water samples taken were analysed by the State Chemical Laboratories in Perth.

In February 1968 the following analyses were made: pH, total disolved solids, NaCl, organic matter (% dry basis), organic N, inorganic N and total soluble phosphorous. Most of these factors were analysed to discover whether there was a change in the productivity of dams in a north-east direction from Pemberton.

For the March 1969 trip water samples were analysed for: pH, ferrous iron, total dissolved salts, NaCl, Ca, and total soluble nitrogen (as a measure of pollution by excretory products of farm stock). Also taken was a sample of the surface layer of mud and detritus, to a depth of 1" from a back corner of each dam where inflow of plant material occurs with runoff of rain into the dam. These samples were taken with a 3" dia. core sampler and analysed for % organic matter on a dry basis by the Chemical Laboratories in Perth.

A considerable amount of rain had, and was falling during the March 1968 trip but the dry season was still in progress during the March 1969 trip.

(b) Sampling of marron.

Young of the year (0+) marron have been found to occupy a different micro-habitat from older marron in the Warren River near Pemberton. Up to about 2 cms, orbit carapace length (early 1+) they are not captured in baited drop nets (¾" nylon mesh), the easiest and most efficient method of catching larger marron. Instead a small mesh (⅜" nylon) long handled scoop-net is used to obtain samples from grass and litter in the water along the stream banks.

These 0+ marron are quite distinctive in appearance from the older marron. They are a yellow translucent colour, have grey markings, and blue chelae.

To date no quantitative method of sampling these marron has been established.

During the first trips in 1968 a scoop-net was used to sample the bottom of the dams around the shoreline for a distance of up to 5' from the bank. Some small marron were also found under bags or other floating objects in the water near the banks. This sampling was sufficient to establish, with a reasonable probability, whether 0+ marron were absent from a dam.

During the 1969 trip up to 15 minutes was spent with the scoop-net searching the side of the dam opposite to where drop nets were being used to catch larger marron.

In some cases very large numbers of 0+ marron were located in a few minutes and in other cases none could be found in 15 minutes of searching.

The abundance of 0+ marron has been estimated in 4 categories as:- "absent", "sparse", "common", or "very dense".

Larger marron were sampled using 5, nylon mesh (⅜") drop-nets, 2' in diameter. Each net was baited with laying-pellets and blood and bone manure held in plastic container at which the marron could feed while on the net.

Drop-nets give very poor catches in clear water streams and dams during the daytime. In these places the best catches are made from sunset, for 3 or 4 hours, when marron commence searching for food.

The farm dams were, however, very turbid. Although very poor catches of marron were made in March 1968, in the 5"sales" dams during the daytime, any doubt concerning the effectiveness of the daytime sampling was removed in 1969 when very large numbers of marron were caught in the "successful" dams of similar turbidity.

The drop-nets were set in March 1968 for 4 hours in each dam and hauled every half an hour. In March 1969 the nets were set for 2 hours in each place, and hauled 4 times.

Orbit carapace lengths and sexes of marron were recorded. Individual weights, and hence catch weights, were obtained by using the equation $W(gms) = 0.9268\, L^{2.86712}$ (cms) calculated from the log-log linear regression using 150 Warren River marron weighed to the nearest ½ gm on an Ohaus Triple Beam balance.

Where there were sufficient numbers of marron, and no competition between marron for the number of drop-nets used, numbers and weights of marron in successive hauls were used to obtain DeLury type estimates of the total population. The esimates were obtained graphically by extrapolation of the trend line relating catch per haul to accumulated catch up to the previous haul.

III RESULTS

(a) "Sales" dams.

The locating of the dams corresponding to the 20 "sales" was attempted during a one week trip. Of these, 19 dams (18 sales) were found and surveyed. All these dams were of the excavated earth type.

The majority of the dams were very turbid, being filled by surface runoff from heavily grazed wheat stubble or pasture. There were no emergent plants in these turbid dams, or filamentous algae, but some dams had a slight bloom of diatomaceous algae. Aquatic animals found in the dams were restricted to only a few types. The most numerous were Corixidae, Notonectidae and Dytiscidae. Odonata nymphs, gammarids, and tadpoles occurred in a few dams.

The majority of dams had a surface area (measured to the high water mark) of 5,000 to 15,000 square feet and were predominantly of the 2,000 cubic yard type (contracted volume of excavated soil) the range being 1,500 (dam 1, Waters) to 7,000 cubic yards (dam 9, Hooper). The surface area is the most reliable and pertinent measure of the size of the dam. The farmers were vague about the maximum depth of their dams. The depth would decrease with siltation to a degree depending on the age of the dam.

The marron from Pemberton had bred in, as far as could be determined, 8 of the dams. Breeding seemed to be restricted to dams closer to Pemberton.

Table 3 gives the results of analyses of water samples taken from the dams. With one exception the data showed no distinctive trends with distance from Pemberton. pH showed a positive trend with increasing distance. There was a distinctive difference between pH determined <u>in situ</u> and pH determined on the water sample some weeks later back in Perth. This difference is thought to be due to uptake of CO_2 in the latter case.

Three of the dams showed high levels of NaCl (dams 1, 11, and 21). Leaking of salt from soils is a major agricultural problem in the area.

The following dams showed characteristics which, at this stage of the investigation, seemed would not favour a successful establishment of marron.

Dam 4; excavated on a steep slope and leaking badly, almost dry and extremely turbid.

Dam 7; shallow, clear water tending to heat up at all depths. Cormorants were present (the dam is close to the Blackwood River system).

Dam 10; koonacs already established in large numbers.

Dam 13; clear water liable to heat up excessively.

Dam 14; too small a number of marron stocked.

Dam 15; koonacs already established.

Dam 18; heavily polluted with sheep droppings and koonacs present.

Dam 19; marron appear to have been misappropriated.

Dam 21; dam almost dry, extremely turbid and contained very large numbers of Gambusia.

Thus, with the exception of dam 15 with koonacs, 8 out of the 20 sales were excluded from further investigation at this stage.

Five dams were chosen from those dams remaining, mainly on the basis of farmer co-operation and spacing along the north-east direction from Pemberton. A dam with koonacs abundant, was included to confirm the unfavourability of this factor.

Dam 1 (Waters). 35 miles from Pemberton. Although out of the flatter country and in the cooler, better rainfall area of the ranges this dam was included because, although of small size (1,500 cubic yards), it was sufficiently turbid to allow day-time sampling.

Dam 2 (Carpenter). A 2,000 cubic yard dam with white pipe-clay banks; 73 miles away.

Dam 3 (Hooper). A large dam of 7,000 cubic yards; 105 miles away.

Dam 4 (Talbot). A 2,000 cubic yard dam; 180 miles out.

Dam 5 (Perrin). A 2,000 cubic yard dam; 210 miles away.

<u>Sampling March 1968 and 1969.</u>

The results of sampling the 5 "sales" dams from 25th to 29th of March 1968 are shown in Fig. 2.

In 1968 O+ marron were sampled in decreasing numbers from dam 1 to dam 3 while none were caught in dams 4 and 5.

In 1968 very few of the original stocked marron were captured (14 males and 6 females in the five dams). These marron were of a larger size closer to Pemberton.

These results could indicate an increasing unfavourability of conditions further from Pemberton or be the result of sending smaller marron to the more distant places where they may not breed during the first year in the dam.

A predominance of males in the "sales" is also indicated.

The method of daytime sampling was upheld in 1968 by the capture of 83 (in the 4 hour sampling) koonacs in Dam 4 (Talbot) and also by the 1969 sampling described below for "successful" dams.

Sampling of these dams in 1969 (March 11-19) showed that there were no surviving marron in Dam 1 (only 4 of the original marron were ever removed by fishing) despite the earlier success. This mortality could be traced to an increase in NaCl from the previous high level of 1540 p.p.m. to 1770 p.p.m.

Dam 2 (Carpenter) showed the densest numbers of O+ marron of any dam sampled including the "successful" dams. There were small numbers of 1+ marron and some original survivors. Only 1 original marron had ever been removed by fishing.

Dam 3 (Hooper) showed small numbers of O+, 1+ and the original marron plus a few koonacs. The farmer had removed 15 of about 5,000 gms. weight (11lb) in 8 attempts with 2 nets.

In Dam 4 (Talbot) the original marron still persisted, with little increment in growth from the previous year, but there were no O+ or 1+ marron. Koonacs were still numerous.

In Dam 5 (Perrin) no marron were captured and the dam was found to be only 3¼' deep by actual measurement from a dinghy (at 11 a.m. on 11/3/69, 22.6°C. at surface and 20.6°C at the bottom).

From this second sampling of "sales" dams, only marron in Dam 2 (Carpenter) appeared to have bred sufficiently to become well established in the future.

The original marron in the dams appeared to have grown very rapidly to legal size or better during their first year in the dams, with the exception of Talbot's dam where koonacs were present beforehand.

During the late March 1968 trip, unlike the subsequent 1969 trip, rain had and was falling. Runoff into the dams had carried considerable quantities of plant debris and small germinating grass seeds from the catchments into the dams where some material was still floating. It was realised at this time that the marron, although omnivorous, must depend to a large degree on this plant material for food in turbid dams. There were not the usual aquatic invertebrates and plants that are linked in food chains in clear still water. Marron examined from these dams, and streams in their natural habitat, have been found to have predominantly plant material in their stomachs.

Direct feeding of marron by farmers at these dams seemed to be desultory and inconsequential. In all cases by the time of the first rains, the plants on the catchments of these dams, dry pasture or wheat stubble, had been grazed by sheep to some extent.

After the 1968 trip there were several requests from farmers in the Great Southern region to identify small eggs which they found covering marron that had crawled out of the water and died. These are the eggs of Corixidae. They appeared to be laid on any solid object in the dam. Marron in Hooper's dam (3) suffered from this attachment. Hooper's dam also contained large quantities of sheep faeces which have been expressed in correspondence with farmers to be a cause of marron failing in dams.

(b) "Successful" dams

The March 1969 trip (during which the 5 "sales" dams were resampled and 7 "successful" dams first surveyed and sampled) was started from the N.E. In the previous year trips started from Pemberton.

Survey characteristics of the "successful" dams are shown in Table 4. The sizes of these dams were similar to those of the "sales" dams ranging from 1,500 cubic yards (Lukins) to 3,500 cubic yards (Graham) with maximum depths of the same order of magnitude. The dams were also quite turbid. They were stocked with similar numbers of marron, for the most part quite recently in the mid 1960's.

Sampling of these dams revealed in every case that marron were well established. Fig. 3 shows the size distributions of marron captured in the dams and Table 5 catch rates and estimated populations by weight and numbers.

The size compositions of the populations in the different dams were dissimilar. The order of presentation of the dams in Fig. 3 and Table 5 illustrates an important phenomenon which has relevance not only to the production and breeding of marron in farm dams but also to the history of wild marron under exploitation in the amateur fisheries in the S.W. of the State.

The addition of "sales" dam 2 (Carpenter) to Fig. 3, as has been done in Table 5, completes the picture.

In the case of Carpenter's dam it was not possible to find DeLury estimates of absolute numbers and weights because of the low density of larger marron present. Similarly Mattiske's dam (1) contained a large biomass of very large marron. These were sufficiently numerous to compete for the number of baited nets used so that there was no decline in the catch rate with successive hauls.

From Table 5 and Fig. 3 it is quite clear that survival of 0+ marron is strongly negatively related to the biomass of larger marron. In dams where marron had had sufficient time to breed for several years the later absence of 0+ marron appears to be due to the accumulation of large marron because of underfishing. For example Mattiske (dam 1) had only taken a few male marron out of the dam in the 10 years of the history of marron in the dam. They had always returned females (sex ratio 1:2 in favour of females in the sampling catches). Ward's dam (6) was a very productive dam as shown by the estimate of organic detritus on the bottom mud, and he could account for 120 marron removed since they were stocked in 1966. The marron had built up to a sufficient density to, as far as could be found, cause a total mortality of 0+ marron. Brown's dam (3) was ½ mile from his house and he only fished it monthly while his dam (4) adjacent to the house was fished weekly. Graham (dam 7) had only primitive wire traps but had transferred many marron to other dams on his property. However, the population of marron in his dam still appeared to be underfished. With Carpenter ("sales" dam 2), Garstone (dam 2) and Lukin (dam 5) very little fishing had been done and the marron were still in the process of establishment. Only 1 marron had been removed from Carpenter's dam, non from Garston's dam and only 8 of the original marron (e.g. see Fig. 3 the single marron of 9.44 cms.) by Lukins.

Using the data for "successful" dams 7, 3, 6, and 1 these waters can accumulate about 1 gm of marron to the square ft. of maximum surface area or nearly 100 lbs of marron to the acre with a slight to moderate fishing intensity. The development of this biomass, however, is done at the expense of the survival of 0+ marron.

These "successful" dams provide clearer evidence of the potential growth rate of marron. For example in Garstone's dam (2) the marron attained 5.5 cms. orbit carapace length (= 3" legal size) in less than 2 years.

There was no opportunity to kill large samples of females for examination of their breeding status. In Fig.3, however, the sizes of all females that were examined are shown together with a distinction on breeding condition. It is evident that 1+ marron were ripening eggs for spawning as 2 year olds. In the Warren River at Pemberton females mature at 2 years, when they reach 3 cms in length and spawn for the first time as 3 year olds. This length is attained at an earlier age in farm dams.

At attempt was made to measure the food available to the marron in these dams. As described earlier it was realised that the food had mainly an external source, being the plant debris and small germinating seeds washed into the dams with run-off from pasture or wheat stubble. It might therefore be expected that, on the March 1969 trip (unlike the 1968 one when the dry season was still in progress) food in the form of decomposing plant material, (plant detritus) would be at a low level. The sample was the first 1" of surface material on the bottom. This sample was always taken about 5' out from one of the back corners of the dams. This position would be where the plant material washes into the dam. It was noticed that drop-nets had higher catches in these corners (the same positioning of the five nets was used in all dams). Several farmers commented that more marron could be captured in these back corners.

The food data show some degree of positive correlation with the size of the stocks of marron in different dams but the relationship is complicated by other factors.

For example, the food value was highest in Ward's dam (6) where the absolute biomass per unit area of water was highest. It was lowest in Brown's dam (4) where the biomass was also lowest but where fishing had been frequent. Growth of marron was highest in Garstone's dam (2) where the food value was high. Biomass was high but the food value low in Mattiske's dam (1) where the growth of marron had obviously been stationary for some time.

Of the "sales" dams Talbot's dam (4), where there were many koonacs, had a very low food value of 0.41, relative to other dams, and growth of marron had been poor. Hooper's dam (3) gave a value of 1.26.

For the dams shown in Table 5 where marron had become established the estimates of abundance were positively correlated with the calcium concentration (Table 6) of the water (see Fig.4). The latter is known to be a limiting factor for the growth, being an essential component of the exoskeleton, and survival, cannabilism to acquire dietary calcium has been indicated, of freshwater crustacea. Recent work overseas has also shown that the rate of decomposition of plant material to a stage of high nutritive value for animals in freshwater, depends on the calcium concentration of the water.

A major discovery was that the "successful" dams were all of one type - white pipe-clay dams.

Of the original "sales" dams surveyed, photographs and notes taken show that only 5 of these were white clay dams. With the original survey numbering these were Dams 5 (Bennet), 6 (Carpenter), 8 (Newby), 10 (Severin) and 13 (Sibley). Dam 13 was a small clearwater dam unlikely to be successful in the long term although surviving marron had spawned at the time of the 1968 survey. Only dam 6 (Carpenter) was included in the subsequent samplings of 5 "sales" dams.

We also came across other evidence of the higher quality of white clay dams for marron on the March 1969 trip.

At Narembeen, where the first "successful" dam was investigated, we found that this dam was one of 33 dams in the area which were stocked with marron from Pemberton in 1964 by a united local effort organized by the local Post-master, B. Bernie. Marron were only successful in 3 of these dams, one of which was Graham's dam. Another of these dams was also seen. It was a white clay dam.

Two dams owned by Nalder near Wagin were in white clay ground and had good stocks of marron as shown by a few minutes scoop netting.

Halloran, south of Kojonup, wrote that of numerous dams stocked with marron, success had occurred only in dams which had milky and opaque water.

Benn, north of Kojonup, has tried marron in 20 dams on his farm. We asked to see the 3 dams where marron had been most successful. These 3 dams were very prominent white clay dams.

Observations during the March 1969 trip after Narembeen revealed that these white clay and quartz dams occured thereafter right through to Pemberton. It was also observed that these dams occurred on rising ground and near the tops of hills while the red clay and laterite dams occurred on lower flatter ground in the valleys and on the flats.

Apparently the white pipe-clay (kaolin) is known geographically as the pallid zone. This zone underlies the red-clay-laterite layer and is, therefore, exposed by weathering on higher sloping ground.

Dams between high and low ground where the surface is laterite may, however, be excavated into the pallid zone and the white excavated soil forming the walls of the dam is then quite distinctive.

Table 6 shows the results of analyses of water samples from all the dams studied in the March 1969 trip. Ferrous iron was not detected in any samples. There does not appear to be any distinctive difference between the red and white clay dams with any of these data.

Farmers had expressed the opinion that white clay dams held water better than red clay dams through the summer. Marron in Graham's dam at Narembeen had, however, survived a drop in water level to a depth of 3'2" in February 1968 and other white clay dams had dried up then. Because red clay dams tend to occur on the lower, flatter parts of valleys the dam waters are likely to be polluted by salt leaching prevelent in such places in agricultural areas. Tests have shown that red clay settles out of suspension much more rapidly than white clay, so that bottom water in red clay dams may become excessively heated in summer if the water is clearer.

There is, therefore, probably no single general reason for the success of marron in white clay dams as opposed to red clay dams. There is also no reason to suppose that the former always have successful waters for marron or that the latter are always unsuitable, particularly in the cooler and wetter areas closer to Pemberton.

The turbidity of farm dams results in a very marked decrease in water temperature with increase in depth from the surface (Table 7). Marron on the bottom near the centre of the dam may thus experience ambient temperatures of up to 10°C lower than at the shoreline during the heat of mid-afternoon in summer.

IV DISCUSSION

A negative relationship was shown between the degree of survival of 0+ marron and the size of the accumulated stocks of older marron in different dams. This relationship has obvious implications for the management of marron in farm dams.

The results illustrate a method of population control by marron. The survival of 0+ marron is reduced when the older marron become more crowded, due to under-fishing, with respect to some resource, probably space (area of dam bottom).

The extreme degree of excessive crowding of large older marron with an absence of small young marron is thought to have been the original status of marron populations in their natural stream habitats in the south west of the State before human exploitation of stocks commenced.

Other studies have indicated that at the other extreme of a nearly complete absence of large marron due to over-fishing, another means of population control occurs when numerous small young marron are crowded, with respect to food, and grow slowly. Only some of the female marron of mature sizes spawn each year (maturity in the heavily fished Warren River near Pemberton occurs at 3 cms. carapace length and the marron may spawn twice at least before legal size of 5.5 cms. is attained). In this unnatural overfished situation this method of reducing the production of marron seems, at least in the Warren River, to be ineffectual.

Again it is possible that the proportion of large female marron (with ripening eggs each year) is reduced where these large marron are crowded with respect to food resources in underfished situations. It is thought, however, that active destruction of 0+ marron is the dominant controlling mechanism when large marron are crowded with respect to space.

Objectives of future work

(a) The reason for the success of marron in white clay dams, as opposed to red clay dams, must be found.

(b) The size of 0+ marron in farm dams is much greater than that of these marron in the Pemberton area. Scoop-net sampling in dams near Kojonup revealed two clearly defined size-groups of 0+ marron in the same dam. The spawning schedule of marron in farm dams should, therefore, be determined.

(c) The management of marron stocks in farm dams requires a more detailed, quantitative determination of the optimum level of fishing intensity. There is also scope for further investigation of the food of marron in these dams and methods of improving food supplies.

V CONCLUSIONS

Summary of factors which are unfavourable for the successful establishment of marron in dams.

(a) Dam too shallow because of leakage, excessive usage, or loss by evaporation in areas far to the north-east. This factor, and also clear water, would lead to excessive water temperatures for marron on the bottom of the dam. Dams which become very shallow also become extremely turbid in most cases.

(b) Dam lacking in cover for marron, particularly if clear, is therefore open to predation by cormorants in areas close to the river systems (e.g. Kojonup area).

(c) Koonacs already established in dams in large numbers appear to cause a breeding failure, and poor growth, of marron.

(d) Sales of very small marron, or too few females, may not allow adequate breeding in the first year after stocking.

(e) Excessive numbers of corixids lead to smothering of marron when the insects oviposite.

(f) Camping of large numbers of sheep on dams leads to excessive pollution of dam water.

(g) Placing a dam in a salt water table leads to an accumulation of salt in the dam which is not tolerated by marron.

(h) Overgrazing of the catchment of the dam reduces the amount of replenishment of plant food for marron each year. Siltation from overgrazed catchments leads to a reduction in the dam depth.

Conditions and methods for ensuring that marron will have a high probability of successful establishment in dams.

(a) If the dam is in a wheat growing and sheep-grazing area such as the Great Southern region, it should be an excavated earth dam of not less than 2,000 cubic yards size. The best dams are those excavated into white pipe-clay so that the dam water is milky in appearance. The low summer depth should not be less than 5' in dryer areas.

(b) The dam water should not be saltier than 100 grains/gallon and excessive pollution of the dam by sheep should be avoided.

(c) Dams containing koonacs or fish should not be stocked with marron.

(d) The holding capacity of the dam for marron should be increased by placing shelters in the water, such as pipes or logs in deeper water for large marron and old bags in shallow water near the banks for small marron.

(e) To combat siltation (which causes shallowing of the dam as it ages) and increase the food supply, the catchment of the dam should be left as heavily grassed as possible, particularly up to the time of the winter rains.

(f) If very numerous small buff-coloured insect eggs are found on sticks and other objects in the water during the late summer months some action is warranted. The adult aquatic insect is about ¼" in length, white underneath, with grey-brown wings, and a pair of oar-shaped legs. Objects such as tree branches should be submerged in the dam and removed when covered with eggs which can be destroyed.

Management of established stocks of marron

During the late summer of each year following the introduction of marron one should look under bags placed in shallow water (near the banks at the back corners of the dam) for small marron ¾ - 1" in overall length.

When the marron have been found to have spawned twice, there are thus three groups of marron; very small ones, as above, ones of intermediate size from the previous year's spawning and the large original marron. The large original marron can then be removed for the ones of intermediate size will breed next year.

The best method of capture of marron, apart from the very young ones in their first year of life, is to use baited drop-nets with a smallish mesh (1").

Always ensure in future years that marron of intermediate sizes, less than 3" carapace length or 6" overall, are present in good numbers, and are returned to the water, but remove all larger marron each year.

Further work on two particular white clay farm dams near Boscabel, after these initial surveys in 1968 and 1969, has shown a number of features concerning the water temperatures, oxygen levels and water turbidities of dams which are important for the summer survival of marron. A brief summary is included in this reprinted report to further aid interested people.

The survival of marron in hot areas is possible because the deeper water in dams remains cool when the surface water heats up during the daytime. The difference in temperature between surface and bottom waters, where the marron survive, depends upon the depth and also the turbidity. The greater the depth and the turbidity the greater the temperature difference. If the water is too turbid however, because of the activities of sheep on the banks and in the shallow margins, the surface water does not cool down to the temperature of the bottom water in the early mornings with the result that mixing of aerated surface water with bottom water, depleted continually in oxygen by the animals living there, does not occur, or too infrequently, and the marron die in early summer (usually).

Another incident which must be mentioned, because it has killed all the marron even in dams where they have been extremely successful, is heavy runoffs of water into dams following sudden, downpours of rain in hot weather during the summer. People who value the marron in their dams should act before summer so that such runoffs will be diverted from marron dams.

VI. REFERENCES

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— SAMPLE RECORD SHEET —

SUCCESS OF MARRON IN FARM DAMS

1. QUESTIONNAIRE:

(a) Farmer's Name ....
Address ....

(b) Date(s) of Purchase of Marron ....
Number and Size Purchased ....

(c) Are the Marron Hand Fed? ....
Type of Food ....
How Often ....
How Much ....

(d) Does the Farmer Fish the Marron? ....
How Often ....
How Much ....
....

2. DAM CHARACTERISTICS: Age of Dam ....

(a) Type. Stock Dam (Excavated stock tank). (Solely dependent on immediate surface run off).............. or Irrigation Dam (Gully Dam). (Permanent or perennial inflow) ....

(b) Dimensions.

Approximate shape. Rectangular ( ) Square ( )
Circular ( ) Ellipsoidal ( ) Triangular ( )
Length (head to dam wall) ....
Maximum width ....Maximum Depth ....
Height of wall above gully bottom ....
Estimated Capacity ....Level ....

(c) Plants: Algae ....
Rooted emergent ....

Aquatic Animals ....

Water: Time of Day & Water Temp. ....
pH ....
Sechii Depth ....
Date ....

TABLE I

AIR TEMPERATURES AND RAINFALL AT TOWNSHIPS IN A NORTH-EAST DIRECTION FROM PEMBERTON

PLACE	Dist. from Pemberton (miles)	Average Air Temperatures (^{o}F)						Av. Ann. Rainfall (inches)
		January		July		Annual		
		Max.	Min.	Max.	Min.	Max.	Min.	
Pemberton	0	81.2	57.4	57.1	42.2	67.7	49.6	51.3
Manjimup	15	78.3	53.7	57.4	42.5	67.7	48.2	42.6
Bridgetown	34	86.0	53.1	59.9	39.8	72.4	46.0	34.6
Mayanup	43							25.0
Boyup Brook	48							27.7
Dinninup	53							24.3
Kojonup	77	85.7	56.5	56.0	41.3	69.9	48.4	21.7
Katanning	102	86.2	55.9	57.9	41.5	71.6	48.1	19.0
Broomehill	102							18.0
Wagin	109							17.4
Narrogin	124	87.5	56.4	57.8	41.1	72.0	48.1	20.0
Wickepin	143							16.8
Yealering	158							14.7
Kulin	174							14.5
Corrigin	182					74.3	48.9	15.1
Kondinin	188							13.1
Narembeen	215							12.6
Bruce Rock	217							13.4
Merredin	245	92.3	61.8	60.1	40.2	76.3	50.6	12.9
Walgoolan	257							11.5
Westonia	266							12.8

TABLE 2

LOCALITY, CHARACTERISTICS, AND MARRON HISTORY OF "SALES" DAMS

No.	Farmer	Place	Dist. of Dam from Pemberton (miles)	Date of Marron Sale	No. of Marron Stocked	Age of dam (yrs)	Dimensions Length x Width	Max. Depth	0+ Marron Located	Comment
1	Waters	Mayanup	35	140167	50	2+	63' x 40'	15'	Yes	Spring fed
2	Forrest	"	38	250267	25	11½	90 x 115	10	-	-
3	"	"	"	"	"	10	95 x 130	15½	-	-
4	Gibbs	Westcliffe	65	140567	50	2	95 x 120	15	Yes	Dam leaking, marron removed recently
5	Bennet	Muradup	68	240267	39	5+	80 x 110	15	-	
6	Carpenter	Kojonup	73	070267	49	4½	100 x 115	-	Yes	
7	Kibblewhite	"	78	050467	50	9	110 x 100	10	Yes	Clearwater
8	Newby	Broomehill	102	240167	50	3	115 x 150	13	-	
9	Hooper	Minding	105	210467	50	6	120 x 190	19	Yes	
10	Severin	Katanning	110	270167	50	9½	150 x 150	15	Yes	Koonacs present
11	Dawson	Congee	120	030367	50	3	76 x 80	14	Yes	
12	Gibson	Narrogin	122	240167	50	5½	100 x 73	15	-	
13	Sibley	Yearlering	160	240167	50	27	75 x 50	7	Yes	Soakage only clearwater
14	Carmody	E. Kulin	180	020567	(50%	D.O.A.	Remainder placed in			two dams)
15	Talbot	Nambadilling	180	090367	50	5	135 x 100	13	-	Koonacs present
16	Connelly	Gorge Rock	180	090367	50	9	130 x 100	14	-	
17	Szczcenski	Corrigin	185	090367	50	15	130 x 230	15	-	
18	Sorenson	Babakin	198	090367	50	10	200 x 100	15	-	Springfed koonacs pres.
19	Allen	Bungulluping	-	-	-	-	-	-	-	Unknown
20	Perrin	Westonia	210	180367	50	5	100 x 135	12	-	
21	Leeman	Westonia	210	180367	50	3½	250 x 150	12	-	

TABLE 3

ANALYSES OF WATER SAMPLES FROM "SALES" DAMS SURVEY

DAM	DAY OF WATER SAMPLING	TIME OF DAY	WATER TEMP. (°C)	SECCHI DEPTH	pH (In Situ)	pH (Lab.)	TOTAL DISSOLVED SOLIDS p.p.m.	NaCl p.p.m.	ORGANIC MATTER p.p.m.	ORGANIC N p.p.m.	INOR-GANIC N p.p.m.	TOTAL P p.p.m.
1	26 Feb.	12.00m.d.	24.7	12"	7.8	6.8	1800	1540	540	4.90	1.75	0.13
2	26	2.00p.m.	20.2	12	8.35	5.5	180	74	120	0.60	0.80	0.23
3	26	2.30p.m.	23.0	16	8.3	7.0	330	194	60	0.35	1.59	0.12
4	26	4.30p.m.	29.0	1	7.8	6.5	280	88	130	0.90	1.24	0.13
5	27	9.30a.m.	18.5	1	8.1	6.9	250	94	60	0.60	1.97+	0.03
6	27	10.15a.m.	20.0	2	7.9	6.6	200	57	40	0.20	0.27	0.58
7	27	12.30p.m.	25.0	24	8.7	7.0	420	143	60	1.10	1.83	0.52
8	27	2.00p.m.	23.0	1	8.0	7.4	670	337	60	0.70	0.58+	0.13
9	28	11.30a.m.	21.5	6	8.05	7.2	140	43	30	0.80	1.13	0.49
10	27	3.45p.m.	27.0	2	8.2	7.2	300	100	40	0.65	0.46+	0.18
11	28	9.30a.m.	18.0	6	8.3	7.4	1760	1280	180	1.35	0.13	0.53
12	28	1.30p.m.	25.0	12	8.2	7.1	210	63	170	1.10	2.43	0.04
13	28	3.00p.m.	26.0	Bottom	8.5	7.6	380	225	90	0.65	0.23+	0.26
15	29	12.00m.d.	19.5	4	8.1	7.8	440	200	50	0.80	0.64	0.19
16	29	1.00p.m.	23.0	1	8.4	8.2	780	150	100	1.25	-	0.78
17	29	10.45a.m.	19.0	3	8.2	7.3	240	57	40	0.50	1.62	0.08
18	29	3.00p.m.	20.0	5	8.3	7.4	1180	677	100	1.25	2.62	0.50
20	1 Mar.	10.00a.m.	19.0	10	8.4	7.8	610	81	130	1.05	0.86+	0.72
21	1	11.00a.m.	23.0	6	8.5	9.0	3950	1110	710	6.50	1.27	0.37

TABLE 4

CHARACTERISTICS OF "SUCCESSFUL" DAMS

DAM	FARMER	PLACE	DISTANCE OF DAM FROM PEMBERTON (Miles)	YEAR OF MARRON INTRODUCTION	NO. OF MARRON STOCKED	AGE OF DAM	DIMENSIONS LENGTH x WIDTH	MAX. DEPTH
1	Mattiske	Kojonup	95	1959 or earlier	-	10+ years	100'x126'	12'
2	Garstone	Katanning	104	1967 transferred	50	2	115 x 130	13
3	Brown	Wagin	127	1965 transferred	20	8	118 x 110	18
4	"	"	"	1964,p	25	v.old	140 x 110	15½
5	Lukins	Kukerin	148	1966,p	24	5	100 x 100	12
6	Ward	Tarin Rock	156	1966,p	50	7	116 x 122	20
7	Graham	Narembeen	221	1964,p	50	10½	160 x 160	14½

(p, from Pemberton)

TABLE 5

SAMPLING ESTIMATES FOR MARRON IN "SUCCESSFUL" AND ONE "SALES" DAM

Dam	Catch Rate(1st Haul)for		Estimated Absolute		Max.Area of dam water (sq.ft.)	Food,% Organic Matter in Mud
	Numbers per Net	Weight(gms) per Net	Number	Weight(gms.)		
Carpenter ('sales' dam 2)	1.2	180	(Total catch 17 in 4 hauls)	(Total catch 2515 in 4 hauls)	11500	1.79
Garstone (Dam 2)	3.2	702	38	9600	14950	2.83
Lukins (Dam 5)	6.2	490	97	5500	10000	1.19
Brown (Dam 4)	5.0	566	41	3200	15400	0.91
Graham (Dam 7)	8.8	748	280	23600	25600	2.82
Brown (Dam 3)	9.4	895	116	10000	12980	2.04
Ward (Dam 6)	8.2	1311	132	14600	14152	8.32
Mattiske (Dam 1)	3.2 (2nd haul)	771 (2nd haul)	(Total catch 53 in 4 hauls)	(Total catch 12070 in 4 hauls)	12600	1.15

TABLE 6

ANALYSES OF WATER SAMPLES FROM
A. "SALES" DAMS B. "SUCCESSFUL" DAMS C. OTHER DAMS
MARCH 1969

DAM	DAY OF WATER SAMPLING	TIME OF DAY	WATER TEMP. (°C)	SECCHI DEPTH	pH (in Situ)	pH (Lab.)	TOTAL SOLUBLE SALTS p.p.m.	NaCl p.p.m.	Ca p.p.m.	TOTAL SOLUBLE NITROGEN p.p.m.	FARMER	GROUND TYPE
A 1	(Mar.) 19	10.00 am	17.8	12"	7.8	7.1	2200	1770	74	2.9	Waters	Grey Pug
2	18	9.45 am	18.3	2	8.1	7.1	170	83	2	2.5	Carpenter	White Clay
3	15	12.00 md	19.5	10	8.0	6.8	220	77	19	4.1	Hooper	Red "
4	12	3.15 pm	20.5	1	8.2	7.8	420	167	8	2.1	Talbot	" "
5	11	9.45 am	21.5	10	8.5	7.9	450	100	21	1.7	Perrin	" "
B 1	16	3.15 pm	27.8	2	8.5	7.1	490	291	15	2.8	Mattiske	White "
2	16	11.00 am	18.6	3	8.1	7.4	210	74	10	1.5	Garstone	" "
3	14	11.00 am	19.3	3	8.3	7.5	440	108	19	2.3	Brown	" "
4	14	3.45 pm	25.5	1	8.3	6.9	520	274	12	5.7	Brown	" "
5	13	4.00 pm	18.0	1	8.2	7.4	350	167	15	2.6	Lukins	" "
6	13	11.45 am	16.5	2	8.2	7.4	510	217	18	3.0	Ward	" "
7	12	9.45 am	19.5	3	7.8	7.8	970	474	32	3.4	Graham	" "
C 1	11	4.15 pm	26.8	9	8.0	7.7	5310	4650	153	3.7	Graham	Red "

TABLE 7

CHANGE IN WATER TEMPERATURE WITH DEPTH
IN "SUCCESSFUL" DAMS

DAM	TIME OF DAY (P.M.)	WATER TEMPERATURE (°C) AT A DEPTH OF (FEET)												
		SHORE-LINE	SUR-FACE	½	1	2	3	4	5	6	7	8	9	BOT-TOM
Brown (4)	4.45	25.5	23.0	22.6	17.3	15.45	15.35	15.3	15.2	15.2	15.2	15.2	15.2	15.2 *(9½')
Mattiske	4.15	27.8	26.05	-	21.5	16.8	15.9	15.65	15.65	15.65	15.65	-	-	15.65 *(7¼')

* MAXIMUM DEPTH OF DAM

FIG.1 NUMBER OF SALES, JAN.-JUNE 1967, NUMBERS IN 50 x 50 MILE BLOCKS.

○/● Sales dams surveyed February 1968
● Sales dams sampled March 1968 and 1969
△/▲ Successful dams for marron located by public appeal 1968
▲ Successful dams surveyed and sampled March 1969

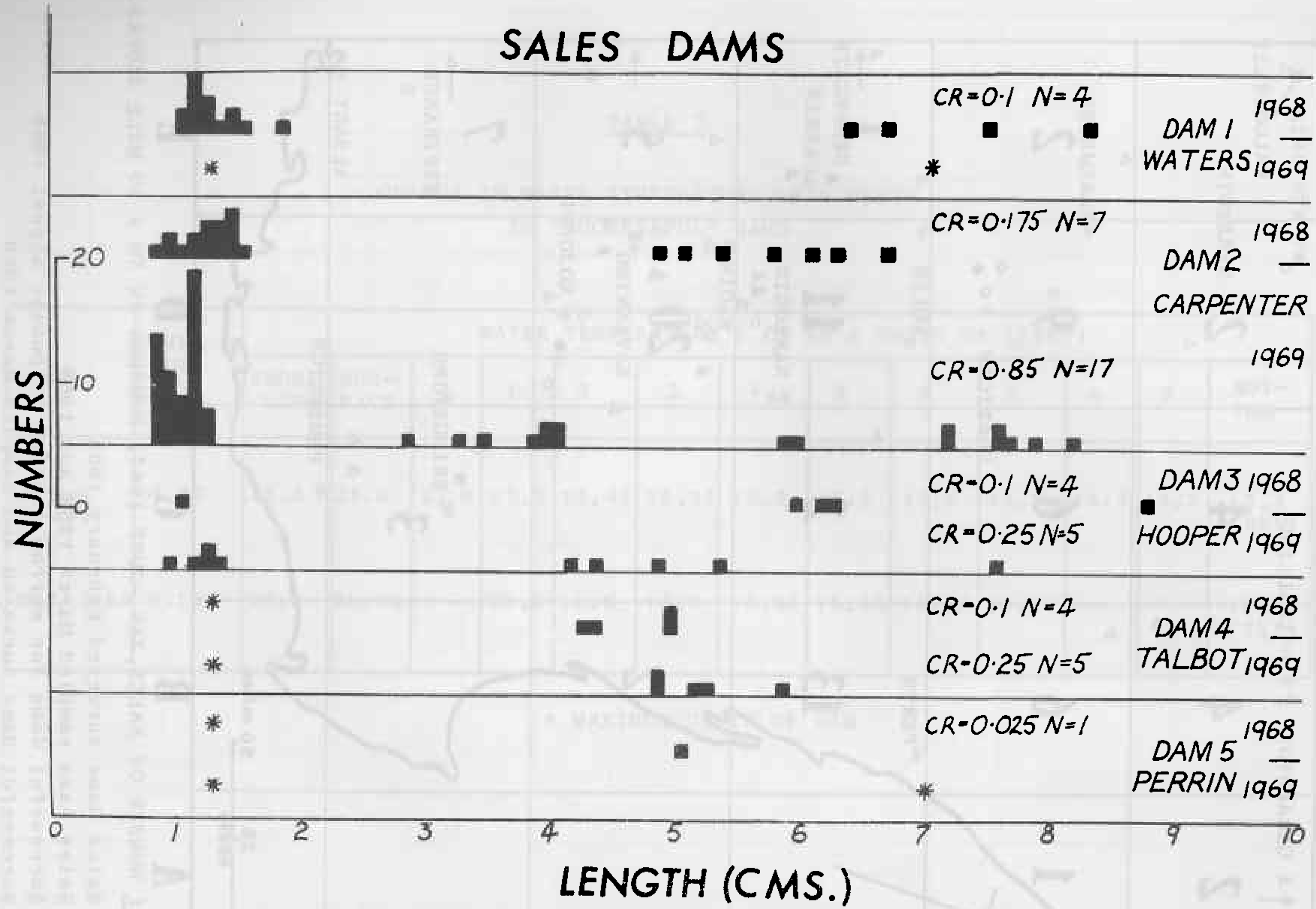


Fig.2 Size distributions and catch statistics of marron sampled from "sales" dams, March 1968 and 1969.

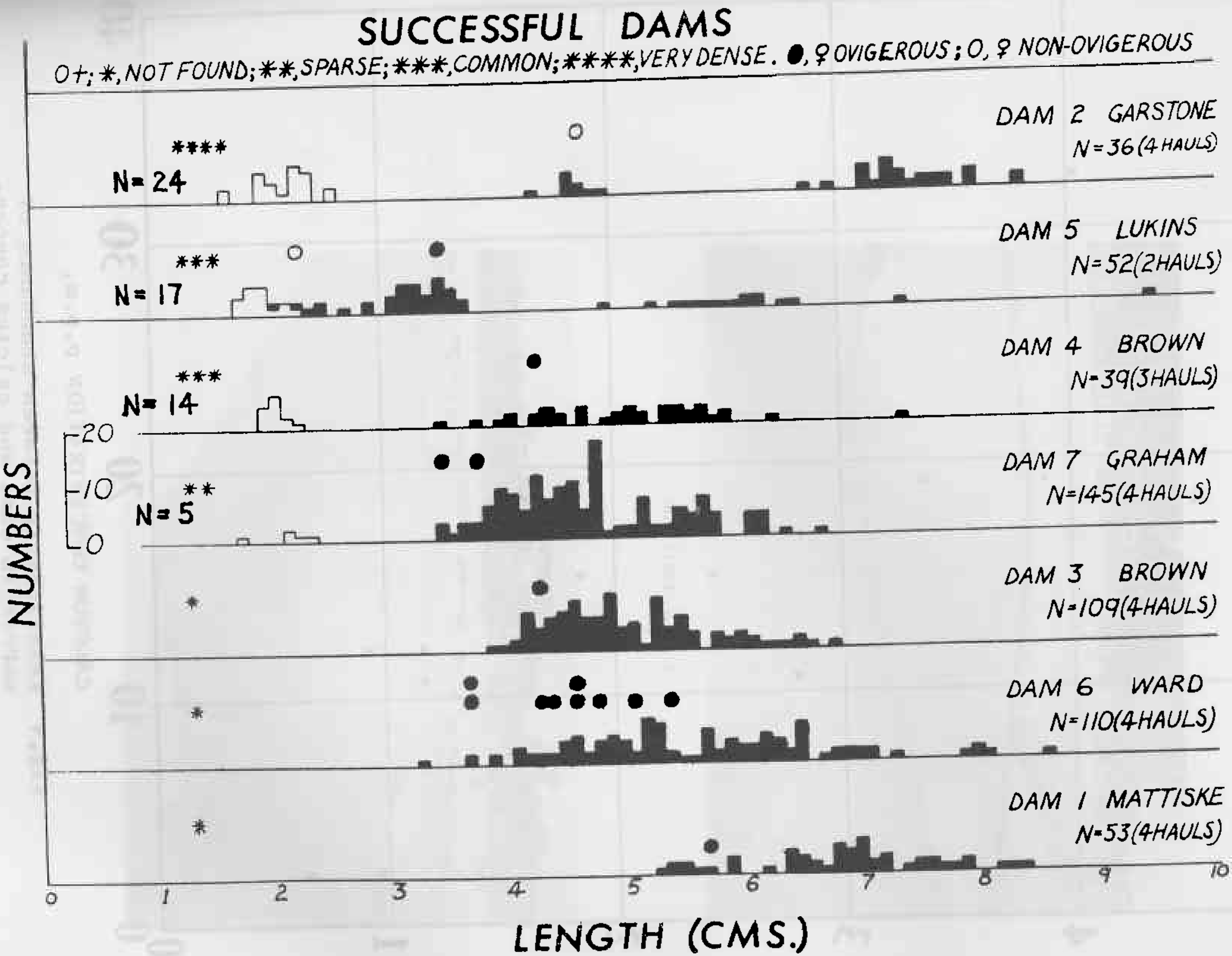


Fig.3 Size distributions of marron sampled from "successful" dams, March 1969.

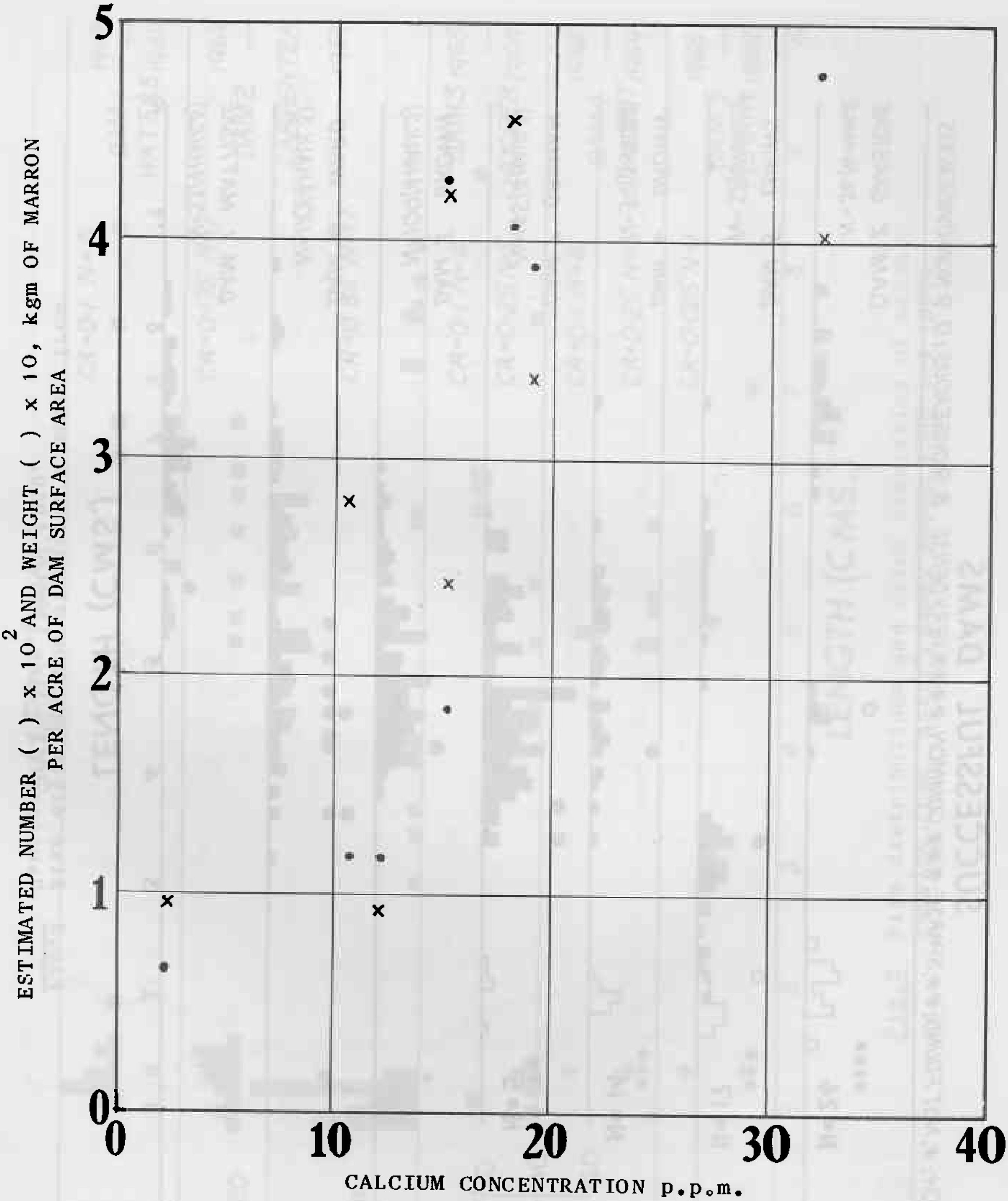


Fig.4 Relationship between abundance of marron in dams and calcium concentration of dam water.

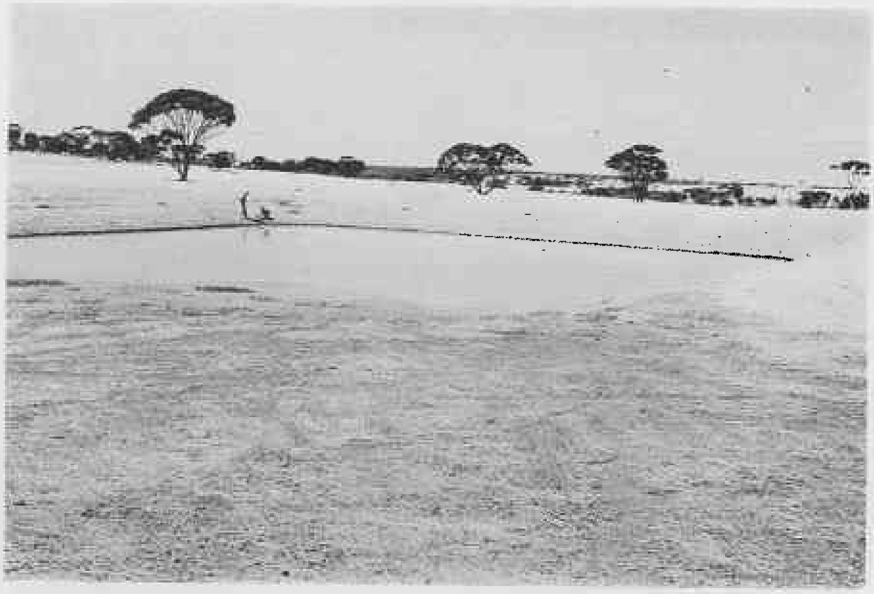
"SUCCESSFUL" DAMS

MATTISKE—Dam 1

BROWN—Dam 4

95587/2/72—300 Bks.

"SUCCESSFUL" DAMS



BROWN—Dam 3

WARD—Dam 6

"SUCCESSFUL" DAMS

GRAHAM—Dam 7

"SALES" DAMS

WATERS—Dam 1

CARPENTER—Dam 2

"SALES" DAMS

HOOPER—Dam 3

TALBOT—Dam 4

PERRIN—Dam 5

Shoreline and Milky Turbid Water in Carpenter's White, Pipe-clay Dam.

Catchment Area of a Dam Grazed Down by Sheep.

Leeman's Dam Near Westonia.

A catch of Marron in Ward's "Successful" Dam.

Distant View of a White Pipe-Clay Dam Near Pemberton.