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THE CHINESE MITTEN CRAB

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[With nine plates]

PREFACE

The assumption that animals settle in new lands beyond the borders of their native habitats and thus extend the range of their habitation often plays an important part in zoogeography. Such assumptions are very plausible in many cases, but they are usually difficult to prove, because these assumed happenings took place so far back in the history of the earth. Extensive studies have been made in our times about animals living in regions far away from their original habitats. Some of these animals have been intentionally transplanted by man and some have been brought in unintentionally on commercial carriers, as on ships, for instance. One of the very best and most recent examples of this is the presence of the Chinese mitten crab in the North Sea and in the Baltic countries following the opening of extensive shipping between Germany and eastern Asia. This mitten crab was almost unnoticed for years but during the latter part of the past decade has increased enormously and has developed suddenly into a serious danger to the fishing industry. The necessity of effectively fighting these obstructive crabs has led to thorough scientific investigations into all their characteristics and everything about them. The lively maritime traffic between Germany and eastern Asia will continue to leave many ways open for the further distribution of this resistant and adaptable crustacean, and a short account of its introduction into Europe, its distribution over Germany and neighboring countries, and its characteristics and ways and habits may be of general interest.

THE MITTEN CRAB'S ORIGINAL HABITAT

The genus *Eriocheir* is a native of eastern Asia and contains three species. The Japanese mitten crab (*Eriocheir japonicus* de Haan) inhabits the Japanese islands from Formosa in the south to the southern point of Sakhalin in the north, also the coast of the Asiatic

mainland across from Japan, the eastern coast of Korea, the coast northward to Vladivostok and perhaps even a little farther north. In Japan it goes far up into the mountains, and in these mountainous regions it is called the mountain crab.

The Chinese mitten crab (*Eriocheir sinensis* H. Milne-Edwards)

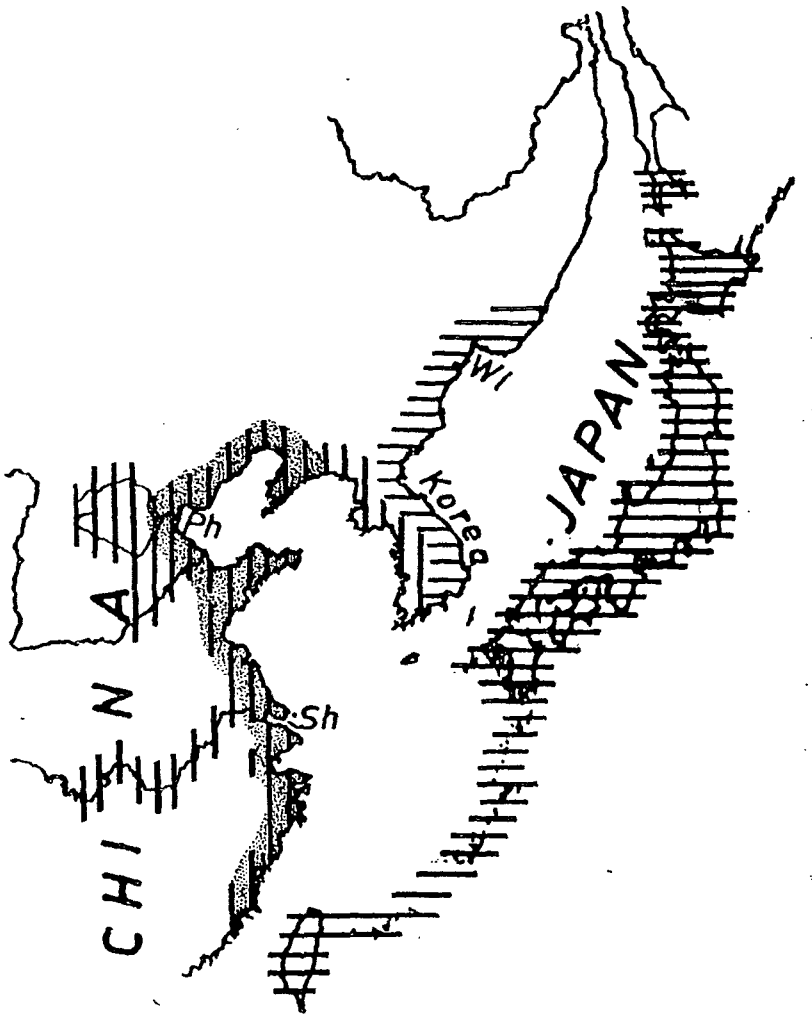

FIGURE 1.—Distribution of genus *Eriocheir* in East Asia; *horizontal lines;* region of habitat of the Japanese mitten crab; *vertical lines:* region of the Chinese mitten crab; *dotted region:* habitat of *Eriocheir leptognathus* Rathbun.

(pl. I) inhabits China from the province of Fokien in the south to the west coast of the Korean Peninsula (by the Yellow Sea) in the north. Its principal habitat is, however, north of Shanghai. Even though it is found far inland, it nevertheless seems to prefer regions near the coast. Kobayashi says that in Korea it always settles in the rice-fields near the coast and that farther inland it lives only in the rivers. The species of *Eriocheir leptognathus* described by Dr. Mary J. Rathbun inhabits China from the province of Fokin in the south, where it is very rare, to the Liaotung peninsula on the Yellow Sea in the north. Its principal habitat is north of Shanghai (fig. 1).

The mitten crab belongs to the Grapsoid family group which is phylogenetically the newest group of the brachyuran crustaceans. The Grapsoid crabs are animals of the Tropics, but a few forms reach into the Temperate Zone, and the mitten crab is one of them. Thus it happens that we see characteristics in an animal living in the Temperate Zone which really belong only to animals living in the Topics. The Grapsoid crabs are marine animals, and it is an outstrnding characteristic of all marine crabs that larvae escape from thear eggs to drift free and pass through various stages before settling ion the bottom. Thereby they differ fundamentally from all real fresh-water crabs which do not go through these stages when the larvae drift. about free. A whole group of Grapsoid crabs spend their adolescence in brackish or fresh water where they find especially rich feeding However, that is the only time they do live in brackish or fresh water. They must always breed in the ocean. The larvae escape from the egg in the ocean and pass through the free-drifting larval stages in salt or brackish water, but however far they may venture into fresh water they must always return to the ocean for reproduction. The Grapsoid crabs, therefore, prefer regions close to the coast when they seek fresh water. Our mitten crab belongs to this group.

HOW THE MITTEN CRAB WAS BROUGHT INTO GERMANY

The mitten crabs live in the Temperate Zone in eastern Asia up into the far north. This fact has made possible their transfer to temperate Central Europe and to cold-temperate northern Europe. Their presence in Germany was probably made possible because of their reproduction through free-drifting larvae brought to Germany on commercial vessels. When the ships happened to fill their ballast water tanks in central or north Chinese ports during the larvae's spawning time, the 1.7- to 5-mm larvae of the mitten crab would, of course, get into the tanks, and again when the tanks were emptied in the German port the young mitten crabs, a few millimeters long, into which the larvae had developed during the trip, would, of course, get into one of the German rivers emptying into the North Sea. This could go on unnoticed year after year. They were undoubtedly brought in long ago. The first Chinese mitten crab, a large male, was discovered in the Aller, a tributary to the Weser, in 1912. One can thus consider that these crabs were first brought in during the first decade of this century, and their entry therefore coincides to a certain extent

with the establishment of intensive maritime traffic with eastern Asia. A specimen was first brought to me for identification in 1923 and a decade and a half or perhaps two may well have passed after they had first been introduced before we became fully aware of this new inhabitant in German waters.

It must seem astonishing that the mitten crab has increased within a period of perhaps three and a half decades in the German rivers in such an alarming degree. This tremendous increase was undoubtedly aided by the fact that they were not brought in fully grown but in large numbers as larvae or when very young. However, this enormous increase in such a short time was above all aided by the particular conditions in the German rivers.

The German rivers ceased long ago to be just rivers and became waterways, navigation highways, and traffic arteries. This change of the German rivers has made existence impossible for many native animals, as, for instance, for the predatory fishes which would have been of the greatest importance in fighting and checking these mitten crabs. Conditions were thus created under which this extraordinarily resistant mitten crab has been able to establish itself.

THE DISTRIBUTION OF THE MITTEN CRAB IN GERMANY

Although the mitten crab was found first in the Weser River system (in Aller near Rethem in 1912), it has not been seen there since. By later questioning Elbe fishermen, it was found that the crabs had appeared as a by-catch in the flounder fisheries by the mouth of the Elbe since about 1915. They seem hardly to have left the lower tide-water region after that. They were first seen in the upper tide-water regions above Hamburg in 1926, and by 1927 they were there in great masses. A few years later they flooded the waters of the mid Elbe (Havel, Province of Brandenburg) to such an extent that it became necessary to take measures to check them. By 1930 the lower sections of the Weser, as well as the lower and mid sections of the Elbe, were thickly infested with these crabs. In the late twenties they began to spread westward into the Ems and eastward into the Oder. They found their way westward from the Weser into the Ems through the many streams and canals in northern Oldenburg and eastward into the Oder through the waterways leading from the Elbe through Brandenburg. And with the beginning of this decade they commenced to spread westward from the Ems into northern Holland and through the Midland Canal and the Rhine into southern Holland, northern Belgium, and northern France. They have gradually established a particular breeding ground in the region of the Danish Great and Lesser Belt in the Baltic. Mitten crabs that had reached the Oder from the Elbe through Brandenburg, have with all certainty helped to establish these breeding grounds inasmuch as, upon reaching maturity, they naturally moved on downstream into the Baltic in their hunt for salt water. And they may have come through the North Sea—Baltic Canal (Kiel Canal) as well. They have spread from these breeding grounds in the Great and Lesser Belt in the Baltic to Denmark, southeastern Sweden, East Prussia, southern Finland, and in some instances, to some of the adjoining countries on the Baltic. Today, according to Dr. Peters, lower and mid Elve as far as into Saxony, the Weser below Bremen, and the coast regions of Germany and Holland from the Elbe to the Rhine are thickly infested with them. In other sections they are only sparse (fig. 2).

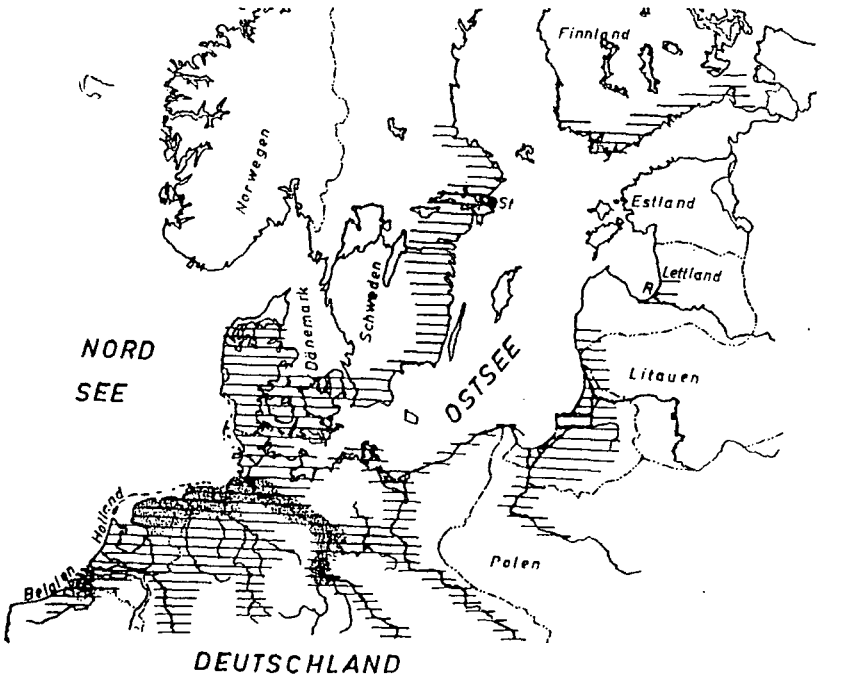

FIGURE 2.—Distribution of the Chinese mitten crab; *horizontal lines:* now inhabited region; *dotted region:* very heavily inhabited.

REPRODUCTION

The mitten crab is, during its whole life, practically a fresh-water animal and is found hundreds of kilometers upstream in thickly infested rivers. With the development of the sex instinct, the urge for the sea also awakens in them, and in August, or after, they leave their feeding grounds, often located far inland, to move on downstream to the sea. The sex organs develop during this migration and the crabs reach puberty on the last lap of the journey through the usually brackish water in the tidal regions. In the fall they always gather to breed in large swarms in the brackish water in the lower course of the rivers.

The males come first and remain through the whole winter while the females come later, mate, and start immediately afterward to move on down to the sea. The eggs are laid within 24 hours after mating and are fastened to the small hairs on the pleopods on the underside of the abdomen with a cementlike substance which hardens in salt water. This cementlike substance hardens only in water that has a salt content of more than 2.5 percent, according to F. Buhk. The females, burdened with the weight of the eggs on the pleopods under their abdomens, choose to stay on in the deep water outside the river mouths through the winter. As soon as it gets warm in the spring, the tiny larvae escape from the eggs to start to drift about free (pl. 2). In all probability the females hunt up particularly brackish water for this purpose. In June or July, after all the larvae have left the eggs, both males and females set out for the river banks at the mouths of the rivers, where they gradually perish.

The intermittent stay in fresh water, and these long journeys far inland between birth and death, which both take place in salt water, bring about the peculiar character of the life cycle of these mitten crabs. They cannot repeat these long journeys to reproduce every year or two, which other crawfishes do, because the distances are too great. Breeding has, therefore, been put off to the last part of their life span. But under normal circumstances this single breeding period is compensated by an enormous egg production. The crabs, males and females alike, are therefore completely exhausted and worn out after mating, and waste away gradually. It is a sign of their generally fading strength that they are so covered with barnacles (Balanidae) (pl. 3) in the summer during their stay in the North Sea shallows, that they hardly move about at all; indeed they often cannot move even their mouth parts. They lack the strength to shed their shells which would enable them to get rid of these cumbersome barnacles.

Whereas the eggs need pure salt water to mature, the larvae leave the eggs in very brackish water. The prezoea, a free-drifting larva, leaves the egg and develops immediately into a 1.7-mm zoea (pl. 2, *a*). Subsequently, three additional larval stages follow. These larvae probably move gradually into less brackish water. The last zoea develops into the final larval stage, the 3–4-mm-long megalopa (pl. 2, *b*). The change from the free-drifting life of the zoea, with long suspended thorns and a rudderlike tail, to the more uneventful life of the crab on the bottom takes place in the megalopa. The megalopa are brought into fresh water with high tide and develop there into tiny mitten crabs, 2.5 to 3 mm long, the first stage of bottom life (pl. 2, *c*).

This migration from salt to fresh water in the larval stage and from fresh to salt water as adults toward the end of their life, is a distinguishing habit of the mitten crab, and, when considered biologically, the mitten crab appears to be in the act of becoming a fresh-water animal. This transition demands important readjustment in their (body) system. Their life substance has the same salt concentration as sea water and therefore differs greatly from that of fresh water. Whereas animals in sea water, with equal salt concentration inside as outside the body, are not imperiled through any osmotic action, life in fresh water demands equalization, and the constant absorption of water by osmotic action through unprotected places in the body, as for instance through the gills, is retroacted by increased water outlet through the kidneys. Otherwise the plasma would be destroyed through continuous swelling. The migration of the tender mitten crab larvae from the sea into fresh water with its added requirement for body functions, therefore, implies strong intrinsic power.

THE BREEDING PERIOD

Although the time of mating and the laying of eggs is fairly fixed, beginning about the end of October and lasting until January, the larvae's hatching time changes very much depending upon the weather. When springs are warm, which does not happen often, at least not in northwestern Germany, the larvae hatch sometime between the end of March and May or June. But the time for hatching usually comes considerably later and lasts until far into July. Thus their whole development is, of course, delayed. During warm springs, the megalopae may appear in July or August in the fresh water below Hamburg, and there develop into the first bottom stage, but during unfavorable weather their appearance is delayed until October. In 1933, when it was exceptionally warm, the young mitten crabs reached an average length of 10 mm in October but again in 1935 and 1936, when the weather was unfavorable, their average size was only 4 to 7 mm when they went into winter rest.

THE WANDERINGS OF THE MITTEN CRAB

The migration of the larvae into the fresh water in the upper tidal regions is (probably) aided by the tidal currents. These feeding grounds are very rich, and the wanderings could have continued to end here, as they did up to the beginning of the twenties, if the number of the crabs had not increased so tremendously. It was this enormous increase that forced them to move on farther upstream in their search for food. But the crabs are too small at first to be able to make their way upstream against the strong current. During their first summer in their larval stage they are brought with the tidal current into fresh water, and during their second summer they stay there in the coast regions where the water recedes at ebb tide until they grow sufficiently to enable them to wander on.

In the late fall the crabs return in large masses to deep water for winter rest, causing such crowding in the narrow river-channels that the young ones, then in their second year, are not strong enough to fight for a place for winter rest there and are, therefore, forced to move on.

Consequently, as the catches by the dam in the Weser by Bremen show, the young animals begin to move on upstream in the beginning of winter but only sparsely during the cold weather in January and February. As soon as it gets a little warmer in March, these crabs, not yet 2 years old, commence to migrate upstream in such huge masses that more than 30,000 of them are caught and destroyed daily in Bremen in traps specially constructed for this purpose. The congestion is lifted when the crabs again swarm out into the shallow regions with the advent of warmer weather in the beginning of May.

These swarms, which once migrated from the tidal regions, are now

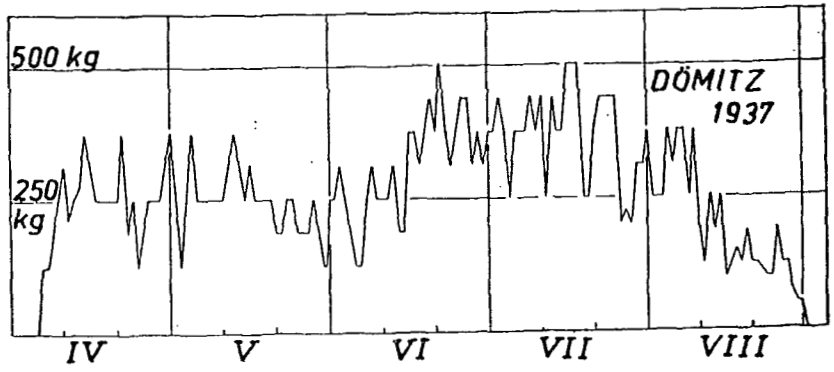

FIGURE 3.—Catch of mitten crabs at Doemitz, Germany, during April, May, June, July, and August, 1937.

forced to wander farther on because rivers that have been converted into navigation arteries do not hold sufficient nutriment for them. It is a wandering without a goal. Wherever a canal, or a rivulet, empties into the river some of the crabs always leave the large swarms to move into it. But in the Elbe, from Hamburg on, they have very few opportunities to branch off into suitable feeding grounds. The crabs heading upstream are, therefore, forced to remain for a long time in huge swarms. Only the Elde near Doemitz (in Mecklenburg), the Havel and the Saole can accommodate these swarms and consequently receive heavy visitations of the crabs. In these three rivers the migration begins in April about the time when it already has reached or passed its height in the tidal region, and continues into August. In Doemitz (in Mecklenburg) 44,400 kg of mitten crabs moving upstream were caught in specially constructed traps by the dam in the Elde rivulet in 1936, and 34,925 kg in 1937. As the curve (fig. 3) shows, the migration and the catch commence suddenly in

April and decrease temporarily during the end of May and early June, probably as a result of a shedding which takes place about this time. The migration is at its height in June and July and falls off during August. The swarms that penetrate into the Havel are even larger. About 100,000 kg of crabs were caught there in similar traps in 1936 (pl. 4, fig. 1). And even as far up in the Saole as Calbe 42,500 kg were caught in 1936. The migration decreases considerably higher up in the Elbe beyond the mouth of the Saole, inasmuch as the greater mass has branched off into suitable feeding grounds. In single instances only do they penetrate as far as through Saxony into Czechoslovakia. The mitten crabs, as we see, indeed, accomplish extraordinary wandering feats. The distance which the tiny larvae travel from the sea up to the vicinity of Hamburg is about 100 km, the distance along the Elbe from Hamburg to Doemitz about 120 km, from Hamburg to Garz on the Havel 220 km, and from Hamburg to Calbe on the Saole 350 km.

I have ascertained through marking tests the rate of speed at which the young crabs travel upstream against the current and in doing this I have marked the backs of 13,000 mitten crabs with good ship's paint of different colors during series of experiments in the Weser, the Elbe, the Havel, and the Saole. The crabs were placed in lots of 1,000 specimens at certain distances apart below the traps and the time was noted when the marked crabs again landed in the traps from which they had been taken previously. The evolution of these 13 experiments showed that the small animals, migrating from the tidal region in the lower course of the Weser, traveled a distance of 1 to 1.5 km daily and that the larger ones, moving against the current in mid Elbe, a distance of 2 to 3 km daily. In their upstream migration, they reach the Havel during the first summer and the Saole during the second summer.

When the mitten crabs have reached their full growth in the interior of Germany, they leave and wander back to the sea to reproduce. A shedding of the shell precedes this downstream migration so the crabs start out with thin, light shells and subtle elastic synovial membranes. The migration commences everywhere simultaneously in August and is in all certainty induced by incipient growth of the sex glands, inasmuch as the sex organs begin to develop in these migrating crabs during their wandering through mid Elbe. The migration downstream decreases slowly in mid Elbe during October after its height in September, whereas the migration continues in its lower course into November. The rate of speed at which these crabs travel has also been ascertained through experiments with color markings (pl. 4, fig. 2). In the course of four experiments, 1,600 crabs were marked and set adrift in the Havel and the Weser. Of the crabs which were captured, the three which traveled the longest dis-

tances had the highest average: (1) Total distance 338 km, time 29 days, or 12 km per day. (2) Total distance 257 km, time 43 days, or 8 km per day. (3) Total distance 368 km, time 38 days, or 10 km per day. These large crabs in the spawning swarm consequently travel downstream at the considerable rate of speed of 8 to 12 km per day and thus can reach the breeding places in the brackish water in 2 to 3 months even from the more remote regions.

It is not surprising that the young animals cease their slow wandering upstream in midsummer when the old animals commence their rapid downstream migration, because the young animals are forced to leave the channel in midstream when the two swarms meet.

SHEDDING OF THE SHELL, GROWTH, AND LIFE SPAN

The vertebrates, with their inner skeletons covered with a network of living cells, grow evenly and inconspicuously, but arthropods, with their dead outer armor, grow by leaps. The chitinous armor reinforced by deposits of lime must from time to time be thrown off and renewed because it ages quickly, breaks and becomes useless. Besides, growth is possible only by shedding the shell because the dead outer shell cannot be enlarged through growth as do the bones of the vertebrates. It must, therefore, from time to time be thrown off and replaced with a new and larger one. Preparation for the shedding of the armor is made in the forming of a new, thin, elastic shell under the old one. The blood pressure now increases through the absorption of water. The old armor bursts in the rear end between the carapace and the abdomen, the crab glides out backward and expands at the same time. The blood pressure produced to burst the old and expand the new shell is so great that the crab after shedding can move on its elastic legs without caving in. The new shell hardens through absorption of calcareous deposits. This peculiar periodic mode of growth with the shedding of the shell restricts the mitten crab to a comparatively slow growth. In growth through sudden expansion, limits are set to the elasticity, inasmuch as overexpansion would tear many organs. According to investigations made by Dr. Schubert, the length added by shedding is 24 percent in the smallest animals but decreases as they increase in size and is only 11 percent in the largest crabs, which are more than 70 mm long. The number of sheddings per year are limited and evidently strictly regulated. The gullet, the stomach, and the rectum, which reaches almost to the stomach, are coated with chitin and are shed with the shell. They must consequently be empty at the time of shedding. The shedding, is, therefore, preceded by a period of fasting. The fasting continues until the jaws harden. According to Dr. Schubert, the mitten crabs shed 6 to 8 times during their first year, 4 to 5 times during their second year, and 2 to 3 times during their third year. The older crabs shed only once a year.

As the hatching of the larvae is usually completed in July, I count the years of life of the mitten crabs as running from July to July. Thus, according to my investigations, the average length of the crabs is: the 1-year-olds about 13 mm; the 2-year-olds about 25 mm; the 3-year-olds about 36 to 38 mm. I estimate that the crabs about 56 mm long in the spawning swarms are 5 years old.

NUTRIMENT

In discussions on the evil of the mitten crabs the question has always been an important one as to whether they attack and eat fishes. It is easy to understand that every fisherman whose catch falls off in vicinities where there are mitten crabs vows that they are wanton destroyers of fishes. But the question is not so easily solved. Timid fishes lose out, to be sure, where there are mitten crabs, and the crabs do attack fishes that have been caught in nets, thus having lost freedom of movement. They are omnivorous and eat whatever they can get. That does not prove, however, that slow mitten crabs catch speedy fishes at liberty. We have, in fact, kept fishes and mitten crabs together for long periods in the same aquarium, a mitten crab and a perch occupying the same corner, the fish directly above the crab without being molested by it. Dr. H. Thiel has proved through examinations of contents of stomachs of mitten crabs that the largest portion of their food comes from the vegetable kingdom, but they must to some extent get their food from the animal kingdom as the lime that is necessary to harden the shell otherwise would be lacking. They eat worms, especially Tubifex, mussels and snails, inferior crustaceans, water insects, insect larvae, and even dead substance of organic origin. Remains of fishes were found only in 4 to 5 stomachs of 1,000 mitten crabs, and these came from a region with huge swarms of young fishes. It may have been the remains of cadavers of young fishes that had served the crabs as food.

VOLUNTARY MUTILATION AND REGENERATION

The mitten crabs, like all higher crustacea, are able to throw off their pincer and walking legs and grow new ones at the same time with their next new shell. This ability enables them often to save themselves when they are attacked. With lightning speed they discard the leg the attacker has seized and then rush off. At the base of all 10 legs, between two joints which have grown together, there is another joint with a very thin shell. Through certain muscular contraction whereby the adjoining leg serves as lever, the endangered leg is broken

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off in this joint. The same thing happens in cases of injuries. The wound caused by the breaking off of the leg is immediately closed with a thin membrane already formed so that all loss of blood is avoided.

Shortly before the next shedding takes place, a bud grows through the scar where the leg was severed and in it is formed a regenerated leg folded in two (pl. 5). It straightens out in the next shedding but is at first somewhat smaller than the discarded limb and lacks always the characteristic pilroe, which makes the fishermen think that they here have an entirely different animal when they find a mitten crab with two regenerated pincers in their by-catch. This lack of pilroe on the regenerated limb is interpreted as a retrogression to an original hairless form, but proof to this effect is lacking (pl. 5).

How much of this self-mutilation is dependent on the ability to renew discarded limbs is realized by the fact that the crabs are very little inclined to self-mutilation when the time for the next shedding is still remote.

MITTEN CRAB BURROWS

It is known that many tropical crustaceans that live in tidal regions on the coast or in the river mouths dig burrows for themselves into which they retire during ebb tide. The mitten crabs do it also in the tidal regions of German rivers. We find their burrows in firm marsh bottoms everywhere on the banks of the Elbe tributaries and in canals which dry out in ebb tide. It is easy to recognize their low and wide entrances and not to confuse them with the round openings to the burrows of the water voles. The burrows are always dug to slant downward and filled with water, which makes it possible for the crabs to await here the return of the water with high tide. Where the burrows are numerous, the undermined shore finally caves in and thus the mitten crabs are the cause of considerable damage in many places (pl. 6).

DAMAGE CAUSED TO FISHING

Fishermen maintain that the mitten crab catches and eats fishes in open waters. However, this does not tally. The healthy fish is much too quick and the mitten crab much too slow for that. Fishermen maintain also that the crab destroys the spawn and the fry. This could hardly be the case either. But in other ways they do a lot of damage, as for instance when fishes like flounders are caught in place nets. When the net reaches the bottom the crabs crawl high up on the net, eating the defenseless fish and becoming entangled with their many legs in the fine net threads. In their attempts to escape they tangle up the nets and finally cut them into pieces with their jaws. To the loss in catch there is added the destruction of nets and the loss of time caused by the constantly necessary mending

of damaged nets. When mitten crabs are caught as a by-catch in dragnet fishing, not only is the fish injured and made useless for sale by rubbing against the crab's toothed armor, but the nets wear out much sooner and must be replaced more often. It is estimated that the resulting cost of nets is tripled in many regions. When mitten crabs come upon eel-basket pots, they swarm into them, attracted perhaps by the scent, and as a result the eels do not go in, or if they do, they are devoured. In central Germany large hoop nets with which to catch the eels heading for the sea are often laid out behind the sluice gate. The crabs migrating in the fall unfortunately take the same route and are consequently caught in these hoop nets. When, as happens in Havel, up to 500 kg of mitten crabs are caught in a single night in a hoop net, the chances for eel fishing are impossible. As eel fishing is the most important source of livelihood for the fishermen in many regions, it is very easy to understand that the fishermen demand that adequate steps be taken to ward off their peril.

MEANS OF CONTROL

It is true that some predatory fishes and some aquatic birds and waterfowl devour the mitten crabs, but this means of exterminating them is altogether ineffective because of the crabs' enormous and rapid increase. The possibility of preventing their reproduction by catching the breeding swarms in the river mouths has been discussed, but however logical the idea may seem, considerable difficulties stand in the way of carrying it out. But more favorable opportunities to control the crabs have presented themselves in the interior of Germany.

The mitten crabs travel on the bottom of the rivers, forcing their way upstream where the current is strongest, and pile up below any dam that temporarily stops them in their wandering. Advantage of this opportunity is taken by the Weser dams in Bremen. Barrels covered with wire netting or canvas are lowered with davits to the bottom of the Weser. The crabs, jammed in against the dam, crawl high up on the barrels, fall into them and are caught in this way. In 1935 from January to May, 12,166 kg of mitten crabs (3,444,680 specimens) were caught, the greatest amount at one time being 407 kg (113,960 specimens) on April 15, 1935. In 1936, 12,786 kg (2,941,100 specimens) were taken.

When crabs are jammed below a dam they try in many ways to get by the obstacle. They crawl up on the walls and finally out on the shore, so as to pass the dam by land. It was thus that it was first learned what enormous masses of mitten crabs infest the German rivers. During warm summer nights the shore region is black with crabs; one cannot take a step without treading on them. In places where a dam is close to a city, it happens occasionally that mitten

crabs land on city streets and finally even penetrate into houses. This happened in 1931 in Rathenow on the Havel, in 1936 in a suburb of Magdeburg, and in 1938 in Calbe on Saole. The habit of the mitten crabs to leave the river bed led to the main methods used in Germany to control them. Where the mitten crabs leave the river in their efforts to get by the obstructing dam by land, extensive shore regions below the dam are shut off by means of sheet iron and trenches dug in the ground in front of the metal into which the mitten crabs fall while wandering along on the sheet iron. Such a project has been laid out by the Elde rivulet in Doemitz and has already been described, and also in Garz on the Havel, where 77,100 kg of mitten crabs were caught in 1935 and 58,300 kg in 1936. In Gruetz on the Havel, 12 km above Garz, a conduit has been led along the upper border of the slanting walled riverbank, and into this conduit the climbing mitten crabs fall and are led by it to a large pit in which they collect without being able to escape. A slanting piece of sheet iron between the conduit and the river prevents the crabs from circumventing the traps. Although here only those crabs are caught which escape the traps in Garz through parallel river beds, nevertheless 11,250 kg of crabs were caught in 1935 and 32,400 kg in 1936 (pl. 4, fig. 1; pl. 7).

In Calbe on the Saole, the mitten crabs preferably climb up the rough slanting wall below the dam which affords these adept climbers sufficient grip. Here large wire baskets have been suspended against the wall and at some distance above them sheet iron has been laid. The climbing crabs slide down this sheet iron and fall into the basket from which they cannot escape. In 1936, 47,440 kg were caught in these baskets during the catching period from April to August (pl. 8).

No special traps need be laid to catch the old downstream-migrating animals. They always move with the strongest current and are therefore caught in front of the turbines and in the eel-basket pots behind the dam outlets. In this way 49,400 kg (about 227,000 specimens) were caught in 1935 in the Havel and 4,814 kg (about 34,470 specimens) in 1935, and 4,836 kg (about 27,560 specimens) in 1936 in Bremen.

These numbers do not by any means include all the mitten crabs caught. The young crabs migrating upstream, which pile up in front of the dam, are often caught there in large numbers in the eel-basket pots kept in front of the dam through the summer. Including these catches, the total catch of crabs moving up and downstream was 137,650 kg in the Havel in 1935 and 129,300 kg in 1936. In verified catches in Germany, altogether 262,600 kg were caught in 1936 and 190,400 kg in 1937.

UTILIZATION OF MITTEN CRABS

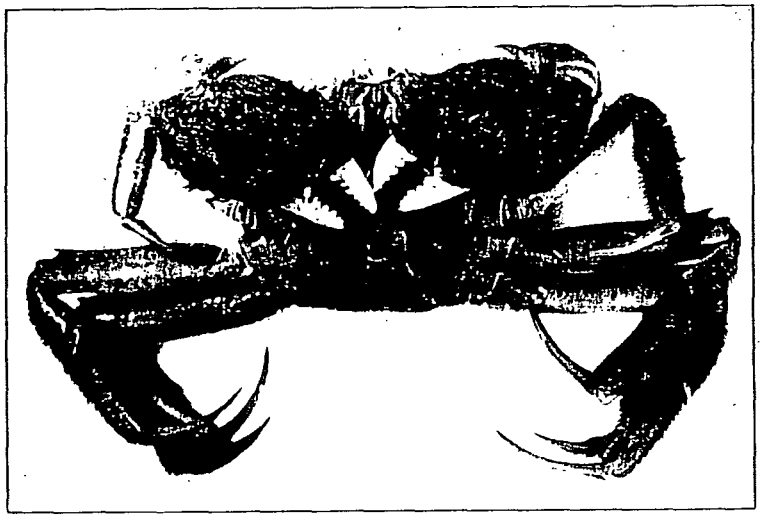
It is evident that efforts should be made to convert into profit these huge masses of mitten crabs caught daily during the main migration period. In Bremen the crabs are boiled and distributed to farmers who feed them to pigs with good success. Many fishermen crush their by-catch of mitten crabs and feed them raw to ducks which understand very well how to pick out the soft substance and thrive well on it. In Garz and Gruetz on the Havel, the mitten crabs are ground in large mills, and when this mutage cannot be fed to ducks, it is dumped into the rivers where the young fishes eat it eagerly. This is, of course, unprofitable and consequently experiments have been made for a long time by the "Havel," an association for the protection of fisheries in Gruetz, which would lead to utilization of the mitten crabs. These experiments have yet not been concluded and, therefore, can not be reported on.

MUTATION OF MITTEN CRABS

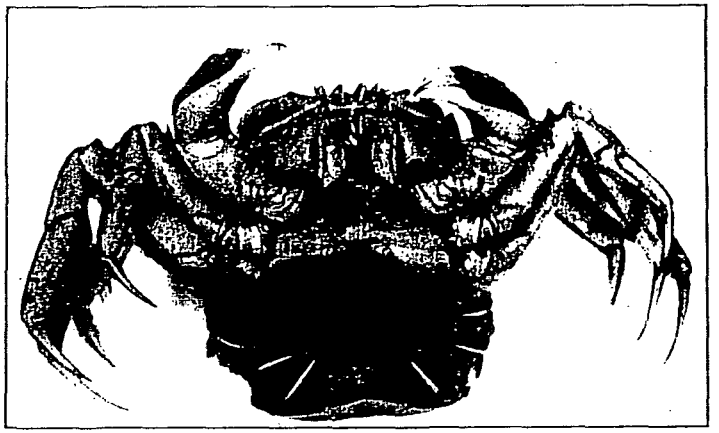
The mitten crabs have reacted to their introduction into a strange environment with some very conspicuous changes in their outward form. Plate 9 shows the three best examples of this change in the form. The changes have taken place principally in two systematically important characters—the rostrum teeth between the eyes and the three pairs of protuberances on the back behind the forehead.

If one assumes that the mitten crabs were introduced into Germany around the turn of the century, it has required a comparatively long exposure to the new environment for these mutations to take place. No traces of changes were noticed in specimens brought to us in the twenties. In 1932 and 1933 the mitten crab was conspicuously labile in systematically important characters. The rostrum teeth were weaker and seldom pointed but mostly blunt, almost round; the indentures between the teeth were flatter and often shaped very irregularly; the protuberances on the back were fainter and those of both rear pairs seemed to be inclined to fuse. At that time it was barely possible out of a large mass of mitten crabs to find even a few typical specimens to be used as exhibits. Now the mitten crab again has its original form without any deviation from the Chinese specimens brought to me only recently from Shanghai. It seems (more cannot be said) that the original mutation was accompanied by a general fluctuation of those characters which were affected by the change.

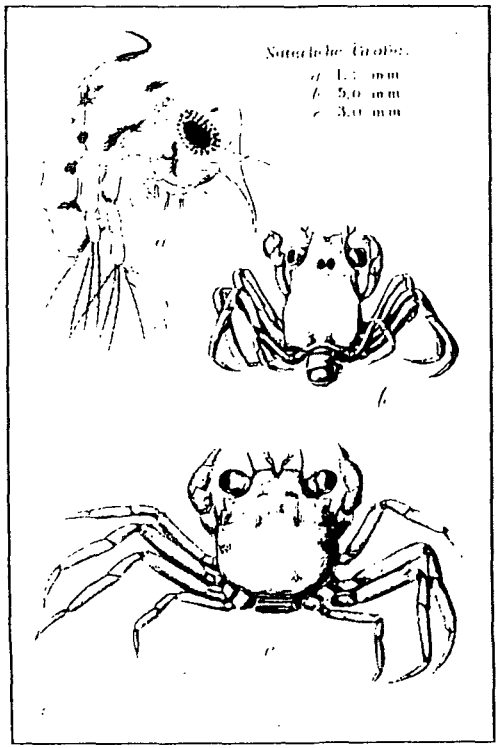
The parts of the foregoing report not based on my original investigations are taken from volume 47 of the Reports of the Hamburg Zoological Museum and Institute (works by Drs. Peters, Thiel, Schubert, Hoppe, and Peters), which I recommend for further information.



Chinese mitten crab, male: *above*, back; *below*, belly.

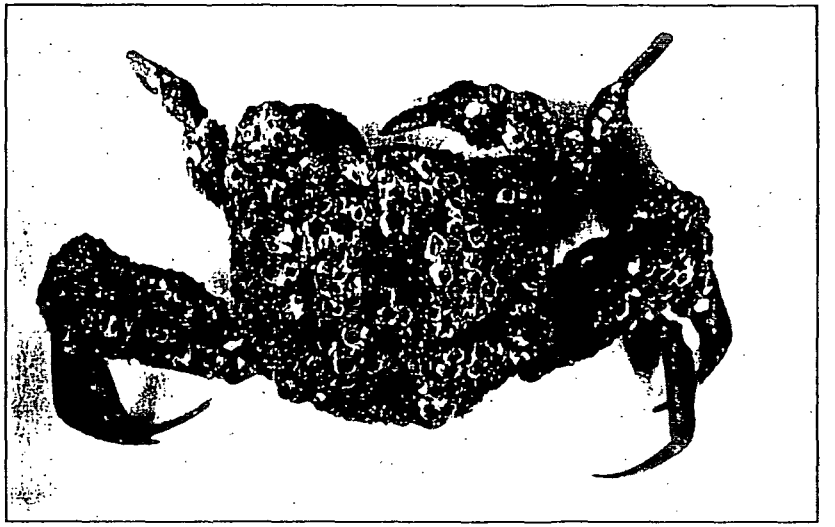


1. Female with eggs.



2. The larvae: *a*, zoea; *b*, megalopa; *c*, in first bottom stage.

REPRODUCTION.

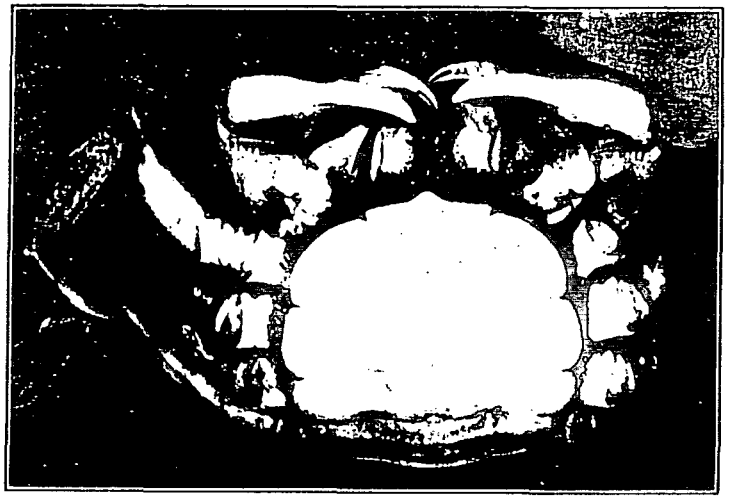


DYING OLD FEMALE DENSELY COVERED WITH BARNACLES.

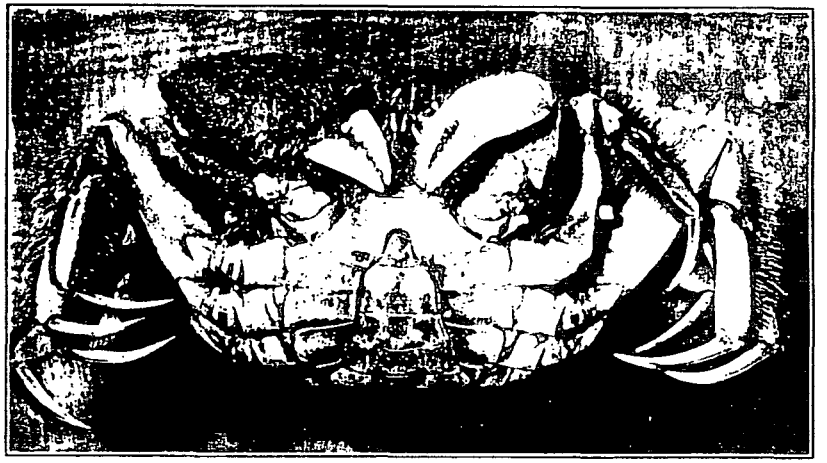
Above, back; *below*, belly; the whole mouth organs densely covered with barnacles and scarcely movable.

1. Catching young mitten crabs wandering upstream into traps by the Havel dam in Gruetz (in Brandenburg) during the summer of 1936. (Photograph by Weltbild.)

2. This large animal marked with white paint was turned loose in Garz on the Havel, recaptured near Wittenberg on the Elbe; it traveled 123 km. in 12 days.



1. Female belly; on the *left side* (right side on the picture), regeneration buds on the stumps of first, second, and third walking legs; on *right side* (left side on the picture), regenerating buds on the stumps of second and third walking legs.

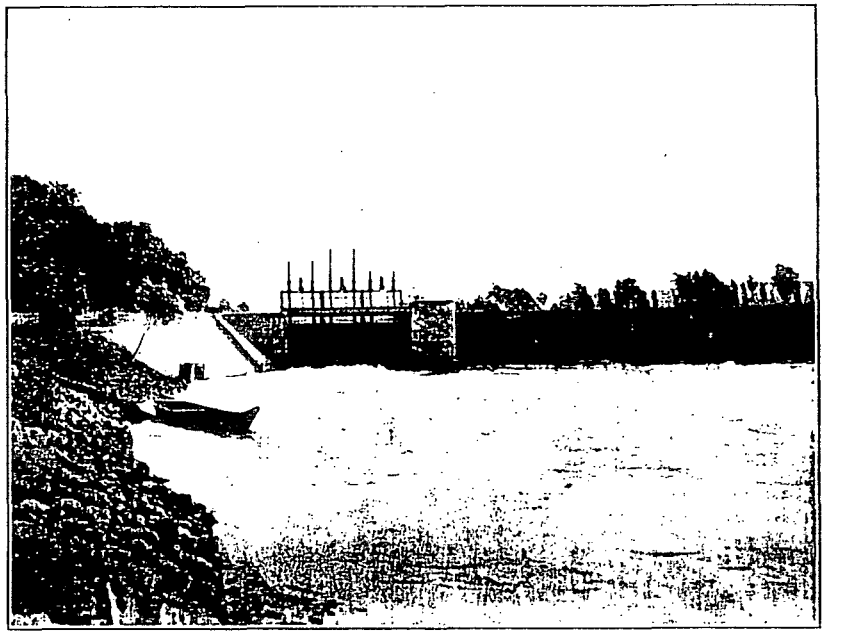


2. Male belly, with newly formed left pincer (right pincer in picture), without hairs, pile.

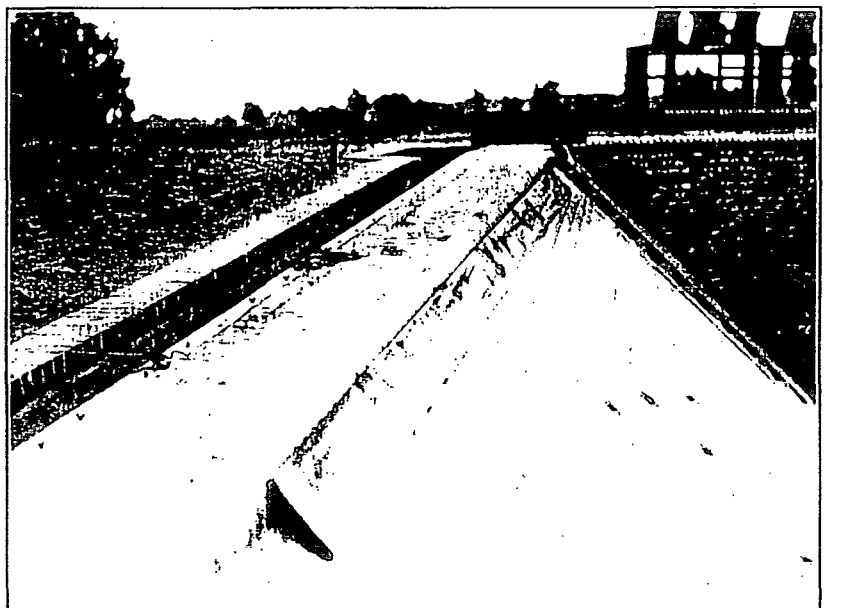
REGENERATION.

RIVER BEDS AT LOW EBB TIDE WITH MITTEN CRAB BURROWS.

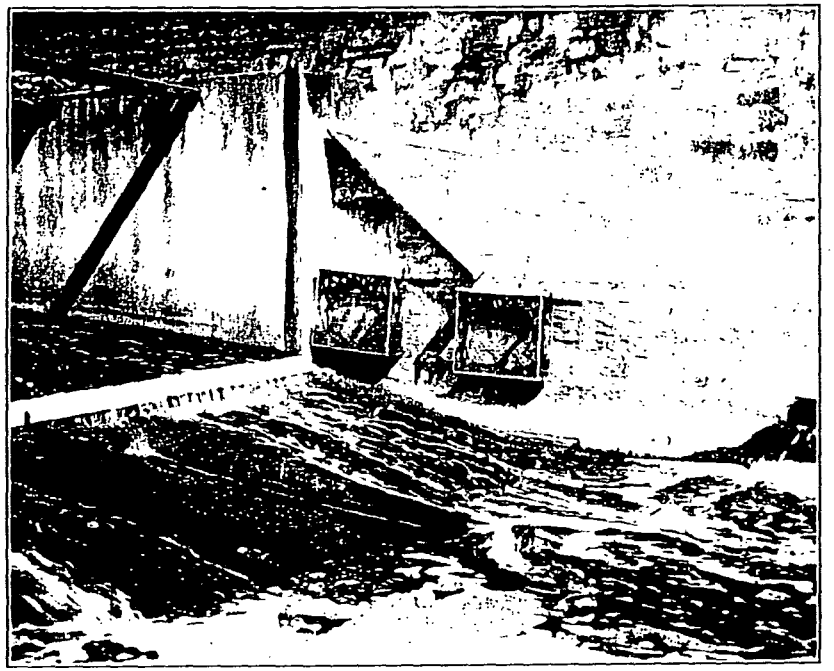
Above, the broad, flat entrances to the burrows; *below*, the undermined bank falls in.



1. The dam in Gruetz on the Havel seen from below; on the right side on the picture the needleweir and on the left side the rampart. Left from it the sloping wall and on its upper edge the trap. (Photographs by Dr. Roehler.)

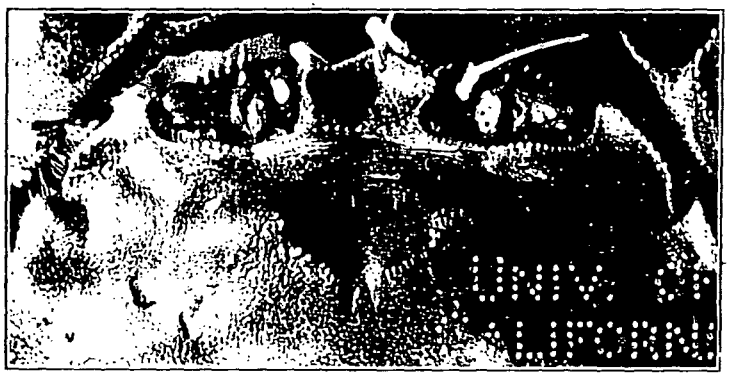


2. Trap projects by the dam in Gruetz on the Havel left wall with trench traps and climbing mitten crabs. (Photographs by Dr. Roehler.)



TRAP BASKETS.

Above, by the dam in Calbe on the Saale; *below*, on the Elbe bridge in Magdeburg. (Photographs by Dr. Kisker.) From Kisker Fischereizeitung, vol. 37, fig. page 510, 1931.



THREE MUTATIONS OF THE MITTEN CRAB FROM THE ELBE.