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STUDY OF LEARNING CAPABILITIES OF TROPICAL CLUPEOID USING AN ARTIFICIAL STIMULUS

by

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RESUME

Nous avons étudié dans des conditions expérimentales l'apprentissage et le conditionnement de petits poissons pélagiques à un stress. Les poissons peuvent être conditionnés et peuvent, apres conditionnement, entrainer des réactions dans un banc de poissons naifs. Nous discutons ensuite de l'influence possible des comportements observés sur la capturabilite.

ABSTRACT

We have studied in experimental conditions the learning and conditioning capabilities of small tropical pelagic fishes on a stress. The fish can be stress-conditioned and those fish can lead to reactions in a "naïve" fish school. We discuss these results and the influence of these behaviours on fish catching.

INTRODUCTION

In order to better surround the importance of individual behaviour of pelagic fishes in the formation, the structure and the reactions of a school, and in order to better define the problems met during their catch, we have studied in experimental conditions the learning and conditioning capabilities of a coastal tropical clupeoid fish: *Opisthonema oglinum*.

The hypothesis is:

Previously stress-conditioned fishes (Pavlovian Conditioning) introduced in a school of "naïve" fishes (non conditioned) can induce alarm or flight reactions in the whole school by contagious effect (Levin and Grillet 1988).

METHODOOLOGY

1. Catching fishes and experimental structure.

The fishes were caught by day in front of the station with a little lift net. Fishing was executed without handling the fish and without emerging them. The fish were carried to the experimental area under smooth anesthesia and heavy oxygenation. A prophylactic antiseptic treatment was applied during the first few days to prevent a bacterian proliferation in the tanks.

Two sets of thirty fish of 15 cm mean length were caught in this way and brought separately and successively into two joined tanks of four meters in diameter and 1.6 high. These two twin tanks in open circuit were strictly identical in shape and colour. The first tank in which takes place the conditioning and the experimental phasis was fitted out with an underwater loudspeaker, a sliding and rigid net laid down on the bottom, and a video camera above. The second tank was bare.

2. Experimental protocol. (Diagram 1.)

The first set of fish were placed in the second tank to be kept on acclimating phasis. These acclimated and non-conditioned fish will be called "naïve" fish. The second set, was introduced in the first tank. During three days of acclimatation, a serie of three sound pulses of five seconds duration and at a frequency of 2500 Hz was emitted in an erratic way (Scharz and Greer 1984). Therefore, we should confirm that this sound didn't involve any fish reactions. Then, we associated these transmitted pulses with a stress. This stress consisted of hoisting the net close to the surface. We could consider the conditioning phasis ends when all the fish reacted to the first sound pulse. We want to determine throughout this phasis, how many repetitions are required for this conditioning.

During the experimental phasis, one part of these conditioned fish was joined with the naïve fish in the second tank, the other part is released. Then, we observed how naïve congenerics react to the flight behaviours of conditioned fish when the sound pulses occur. In the second phase, we removed this dual school back to the first tank in order to measure a possible tank effect.

3. Behaviour criteria held.

Each record of ten minutes was divided into three periods: before, during and after the inductive factors (sound pulses only or sound pulses followed by the stress). For each period, the cohesion and the activity of the school were measured through eight behavioural criteria.

The cohesion and stability criteria of a school are in decreasing order:

- the structure in MILL where the fish swim slowly in circles. This structure is considered as a behavioural form of protection. It is a good index of stability and defence of a school.

- the structure in SLACK SCHOOL where the interindividual distances are approximately equal to the body length and where the swimmming speed is slow.

- the structure in DENSE SCHOOL where the interindividual distances are short and the swimming speed is faster than in a slack school.

- the DISPERSION where no fish swim in the same direction in group.

The activity behaviour criteria of the school are in decreasing order:

- the ALARM REACTION which affects only one fish and which doesn't induce reaction towards the other.

- the FLIGHT REACTION WITH REGROUPING.

- the FLIGHT REACTION WITH DISPERSION.

We measured the occurences and the durations for each criterion in each period and also the same thing for the sum of all the reactions.

RESULTS

1. Acclimatization phasis.

First, we noticed that no mortality and no unexpected behaviours occured during the experiment. Therefore, we consider that the fish have adapted correctly to their captivity.

The tests on fish during each sound pulse show that the reaction is low and decreases during this phasis. The last three tests show no reactions on any pulse. Therefore, the sound pulse is considered as a neutral stimulus.

2. Conditioning phasis.

In order to follow the evolution of conditioning, we set up a table of weighting factor taking into account both the reaction ways (increasing from agitation to flight and dislocation) and the running number of sound pulse (increasing factor from pulse 3 to pulse 1). These values are shown in the table 1.

The reaction curve rises up to the maximum at the end of the phasis (Fig.1). The fish react earlier and earlier to the stimuli. The evolution of reaction ways is gradual in the case of the first sound: at first, alarm reactions occur with excitement, then flight reactions with a dislocation of the structure, and finally flight reactions with regrouping. During the same phasis at the moment of pertubation, both the duration of mill structure and the regrouping flight reaction increase. (Fig.2 and 3).

Then, the conditioning should be accomplished at the same time by an increase of the individual sensibility to the stress and an increase of school stability, it's cohesion and defence.

3. Experimental phasis.

With the same criteria used during the conditioning phasis, we analysed the reactions of the mixed school on the stimuli. They were null and void during the first phasis when the fish were introduced into the first tank. On the other hand, we observed flight reactions and dislocation at the beginning of the second phasis when we put the fish back into the second tank. These reactions whittled down quickly until they just became individual alarm reactions in the end. (table 2). During the same phasis, at the moment of pertubation, the duration of dispersion decrease while the duration of mill structure increase. (Fig 4 and 5).

In first analysis, it seems that the reaction of the mixed school is low. This school acquires a strong stability and cohesion at the end of this phasis.

DISCUSSION

The first question is: can the fish be conditioned? i.e., in our experimental conditions, are they able to recognize a sound emitted in the water and associate it with a further event (here: a stress)?

In the case of a positive response, the following questions are:

- how is this association (stimulus-stress) self made ? i.e., how does the reaction to the stimuli evolve during the conditioning phasis ?

- how many repetitions does it take for this conditioning ?

The results show that the conditioning of fish is possible. The interesting fact is that the conditioning to a stress doesn't lead to panic in individuals but to a strengthening of the school cohesion in their flight reactions. This panic might be obtained with a stronger intensity of the stress and with a longer conditioning duration. In any case, we did not obtain a stabilization of the reactions at the end of the conditioning phasis. Therefore, a stronger conditioning should require more than fifteen repetitions.

In the second part of the experience, we tried to answer the following questions:

- Do the conditionned fish introduced into a "naïve" fish school react to the conditioning stimuli?

- If so, how long do they react ? - Do the flight reactions of the conditioned fish induce a reaction in the whole mixed school? - What are these reactions?

At the begining of the experiment, when we add a part of the conditioned fish with the naïve fish, we do not observe any reaction from the mixed school. To account for this result we may consider the following explanations. First, the stability and the cohesion of the school are so strong that the conditioned fish are completely wrapped up in the naïve school and cannot react to the stimuli. This is speciallv plausible because the school are usually in mill structure. The formation of this structure was described first by Breder (1951). It happens frequently after a short period of "confusion" in which the school is temporarily disrupted, with fishes pointing in all directions. We think for this reason that this structure ensures good protection for all the congenerics . In this case there is a huge school inertia, and the group effect is preponderant in front of the individual effect.

Secondly, the conditioned fish hear the stimulus but do not react because they are not in their own tank. So, in a second phasis, we put the whole school back into the conditioning tank. During this the second phasis, at the beginning, the school reacted to the stimuli then this reaction decreased rapidly. This second phasis demonstrated that the previously stress-conditioned fish were still conditioned because they react to the stimuli. Then, they were able to induce a flight regrouping reaction of the mixed school although the mill structure should set oneself against it.

In this case, the individual effect is preponderant in front of the group effect but, the flight regrouping reaction appeared during the first four sets of sound pulses after a great part of the presumedly stress-conditionned fish reacted. At the end of the experiment we recorded alarm reactions from some of the fish which did not induce flight reaction of the school. Therefore, we presume that a threshold proportion of the group must be stressed in order to induce a flight reactions of the whole school. That means that the leading reaction inside a school requires a threshold proportion of conditioned fish. In our experiment, this threshold is only reached when all the stress-conditionned fish react.

If the reaction decreases rapidly it may be due to the short time of conditioning or the weakness of the stress (in order to avoid hurting them, the fish were not emerged).

To explain the differences between the two tanks, we can assume that a visual relay is required to recall the conditioning to the previously stress-conditioned fish. Without this relay, they cannot react and so, do not lead the whole school. In our experiment, this visual relay could be the net laid down on the bottom.

CONCLUSION

The conditioning of a fish school is possible under experimental statements. We have seen that the essential statements for learning and conditioning are a sufficient intensity of the stimuli and a relatively high number of repetitions. Without these statements conditioning should be impossible in the natural environmemt. These conditions are found in intensive fishing areas where a lot of ships sail, fish and trawl. Therefore, we shall have to observe in other experiments if the increase of both intensity and duration of the stimuli could induce a better learning and conditioning.

In our experiments the leading of naïve fish by conditioned fish seems to require a visual relay in front of the strong inertia of the school. To examine this hypothesis we could put another net on the bottom of the second tank (previously bare tank) before the experiments and observe the reactions of the mixed school. In the natural environment these kind of mixed schools should exist. Indeed, we can imagine that inside the distribution zone of a fish stock, there is a restricted exploitation area (which could be for example the nursery) where we can find more conditioned fish than in the nearby areas. By means of migrations inside the distribution zone, these conditioned fish can mix with naïve fish. So, the catchability of fish inside these stocks could be lower than in "wild" stock.

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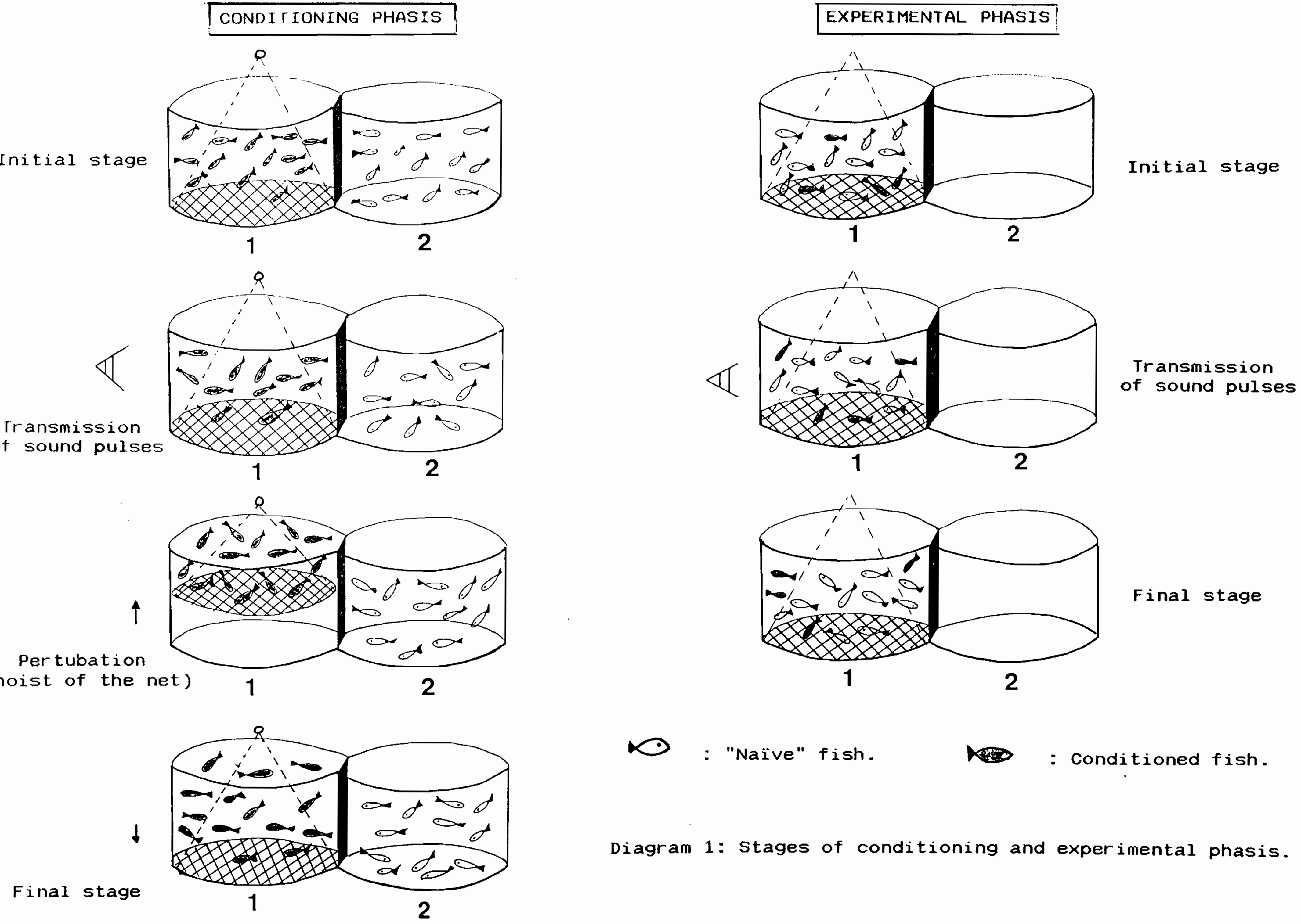


Diagram 1: Stages of conditioning and experimental phasis.

Fig. 5. TVG for EY-M large beam transducer
Cuba, october 1989

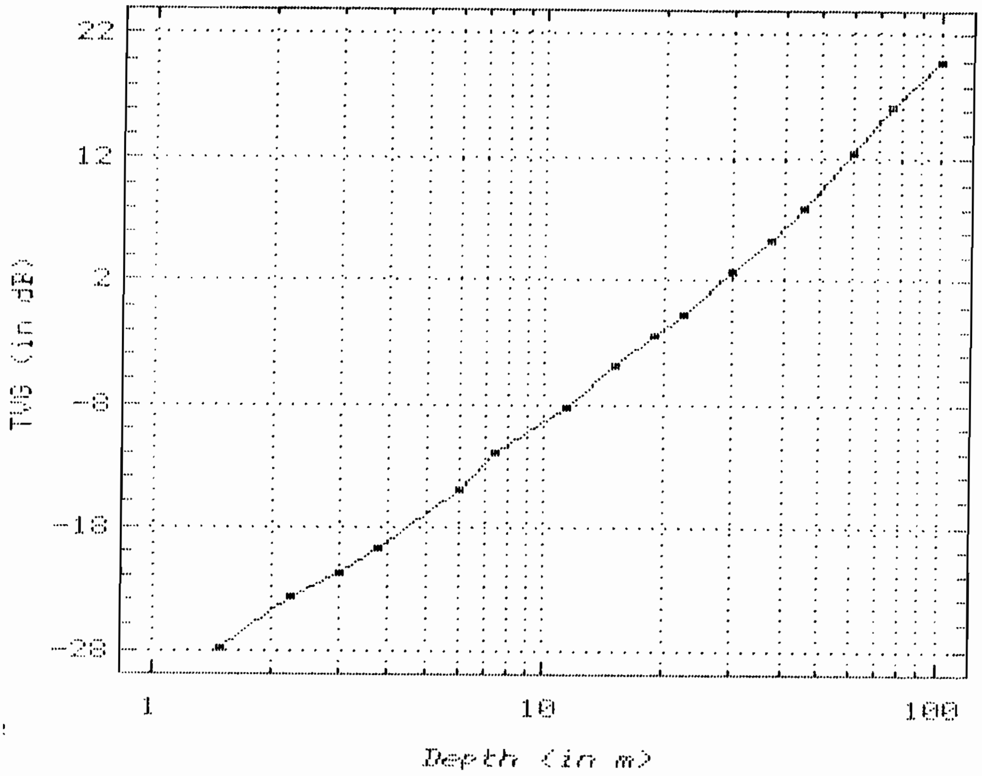


Fig. 6. Frequency Histogram of Fish echoes
Gulf of Batabano, oct. 1989

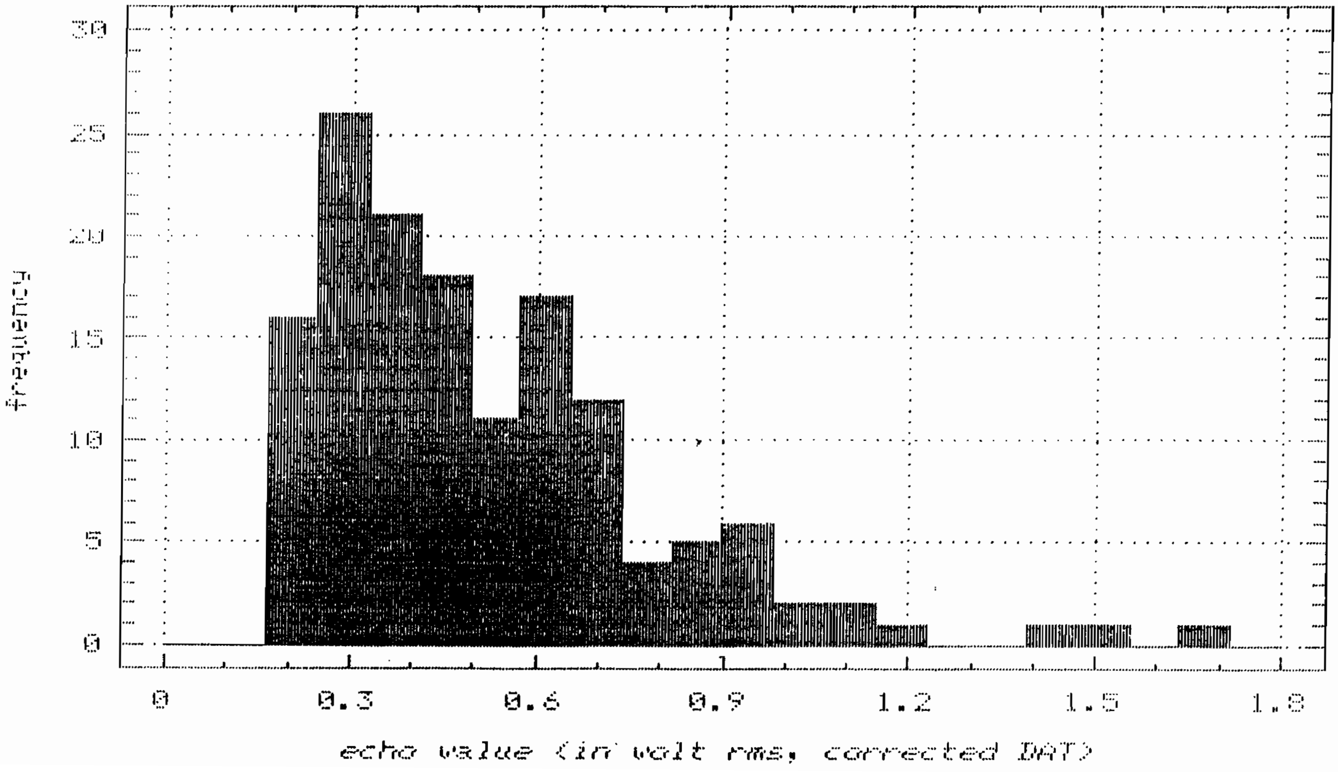


Fig. 7a. Frequency Histogram of fish TS
Gulf of Batabano, oct. 1989

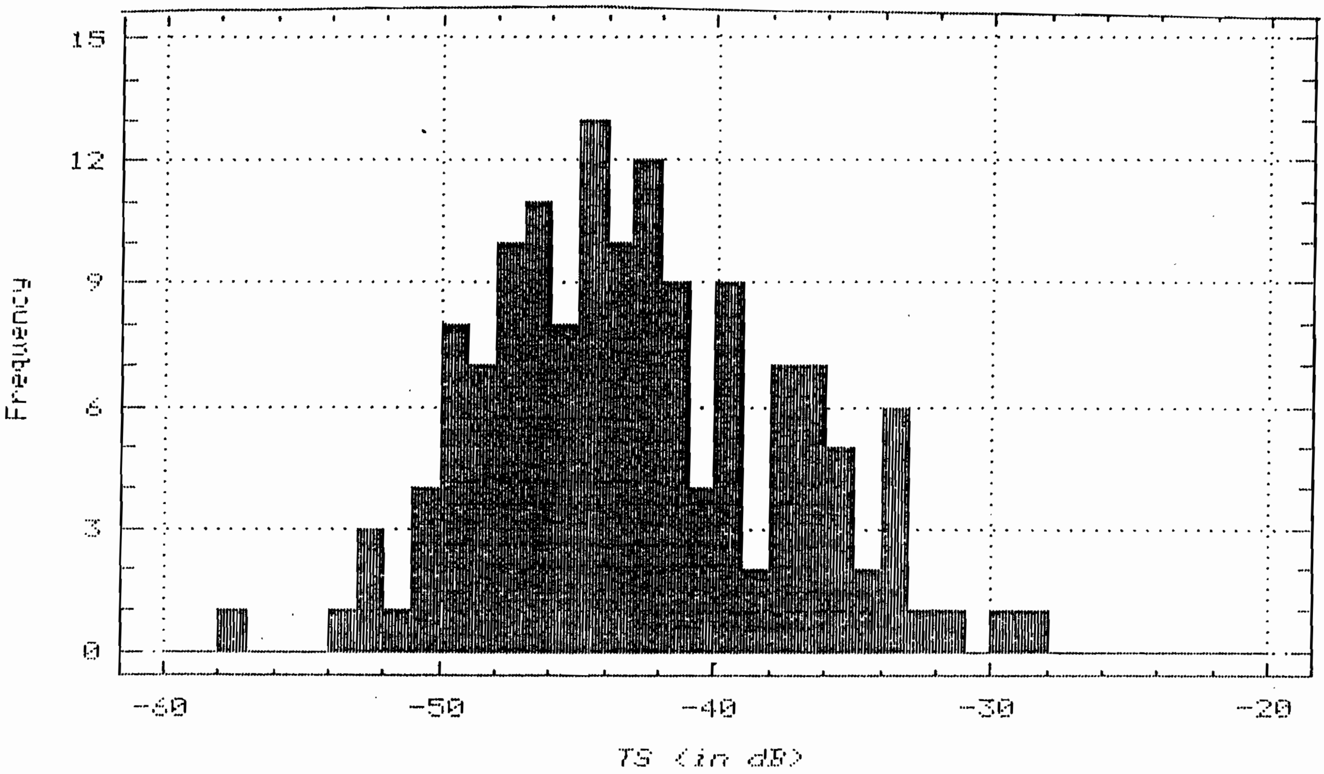
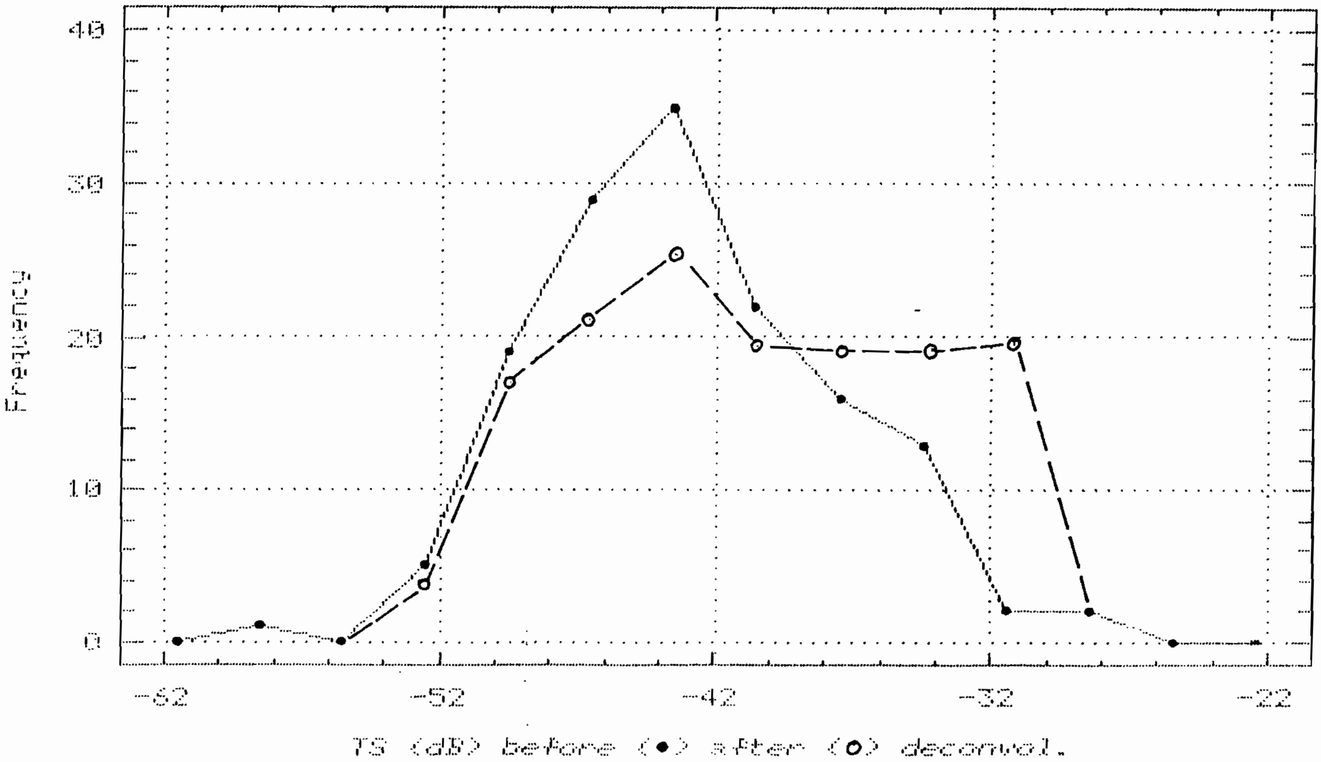


Fig. 7b. Frequency Polygon of fish TS
Gulf of Batabano, oct. 1989



	SOUND PULSE 3	SOUND PULSE 2	SOUND PULSE 1
FLIGHT AND DISLOCATION	4	8	12
FLIGHT ***	3	6	9
DISLOCATION **	2	4	6
AGITATION *	1	2	3

Table 1. Scale of values of the conditioning in terms of reaction ways and reaction time.

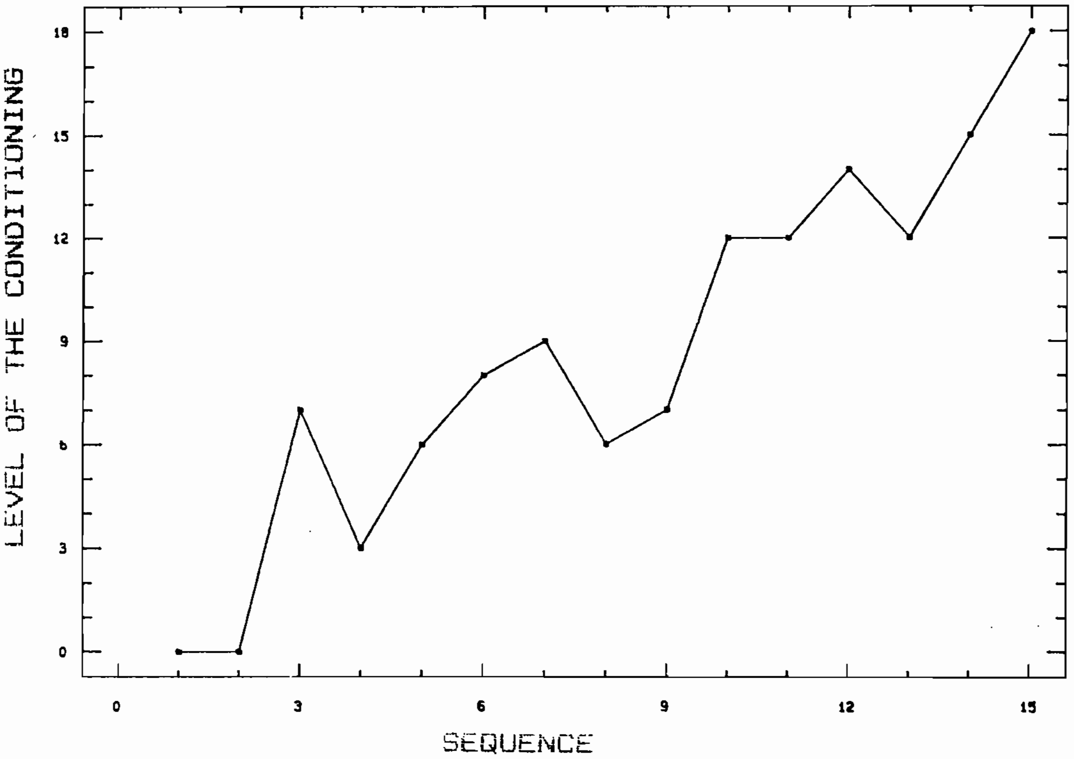


Fig 1. Evolution of the reaction during the conditioning phasis at the moment of the pertubation.

REPETITION	SOUND PULSE 1	SOUND PULSE 2	SOUND PULSE 3
1	/	**	***
2	***	***	***
3	/	/	**
4	/	/	**
5	/	/	/
6	/	*	*
7	/	/	/
8	/	/	/

Table 2. Levels of reaction during the second part of the experimental phasis.

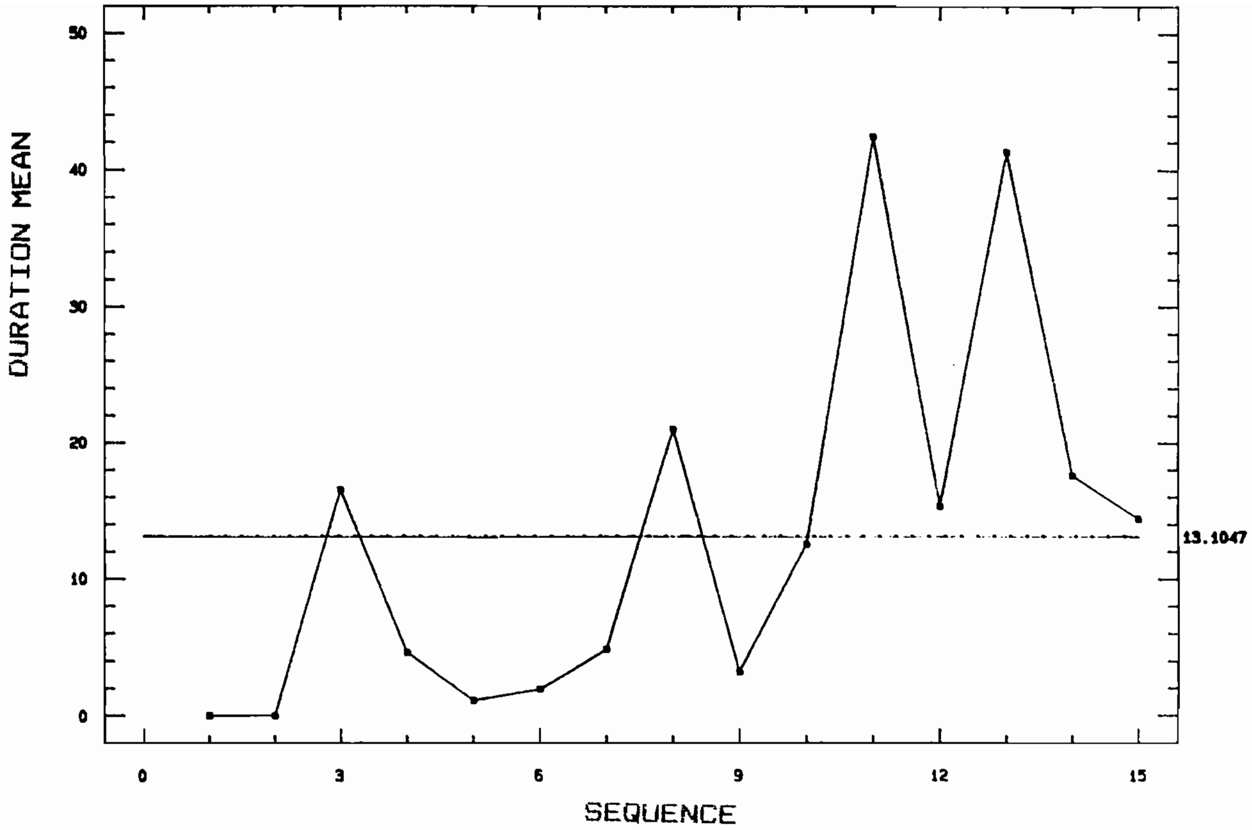


Fig 2. Evolution of the MILL structure duration during the conditioning phasis in the periode of pertubation

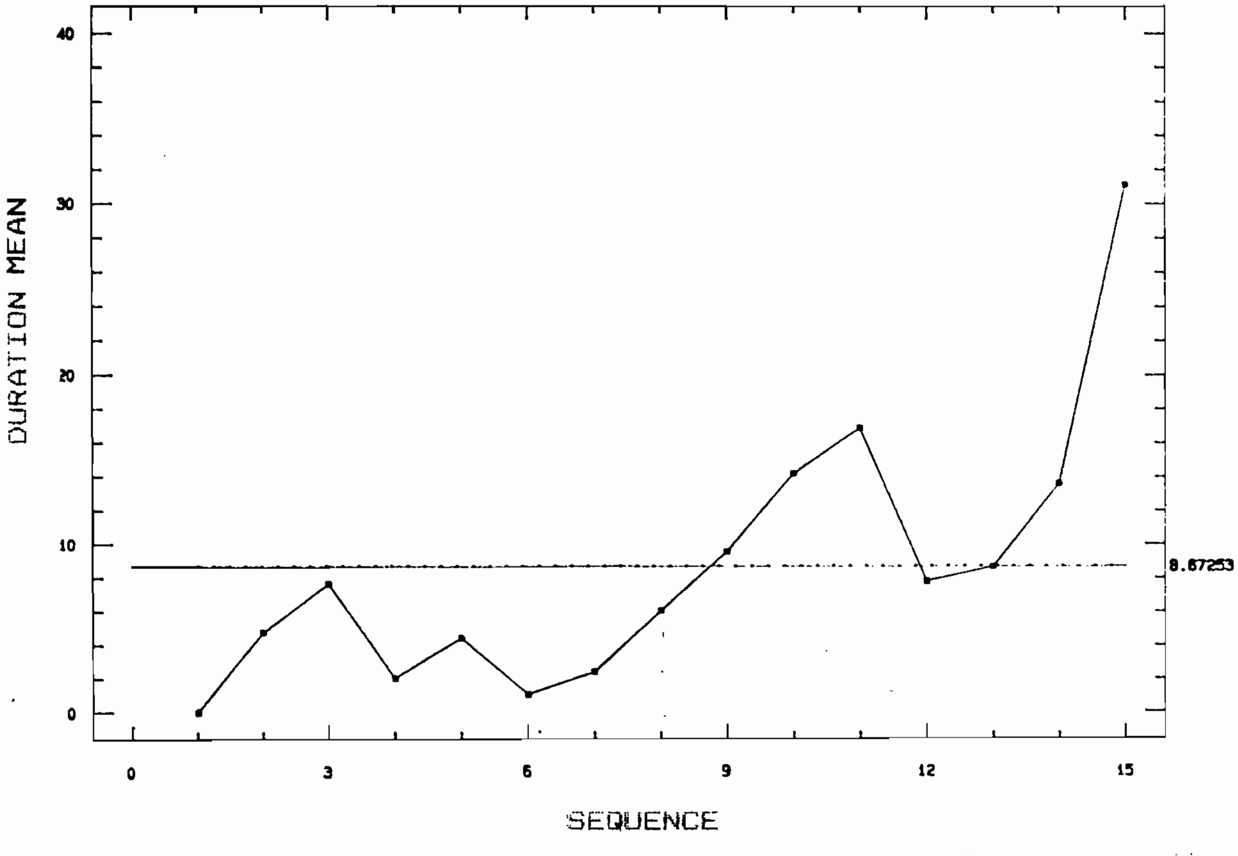


Fig 3. Evolution of tne regrouping flight reaction during the conditioning phasis in the periode of pertubation.

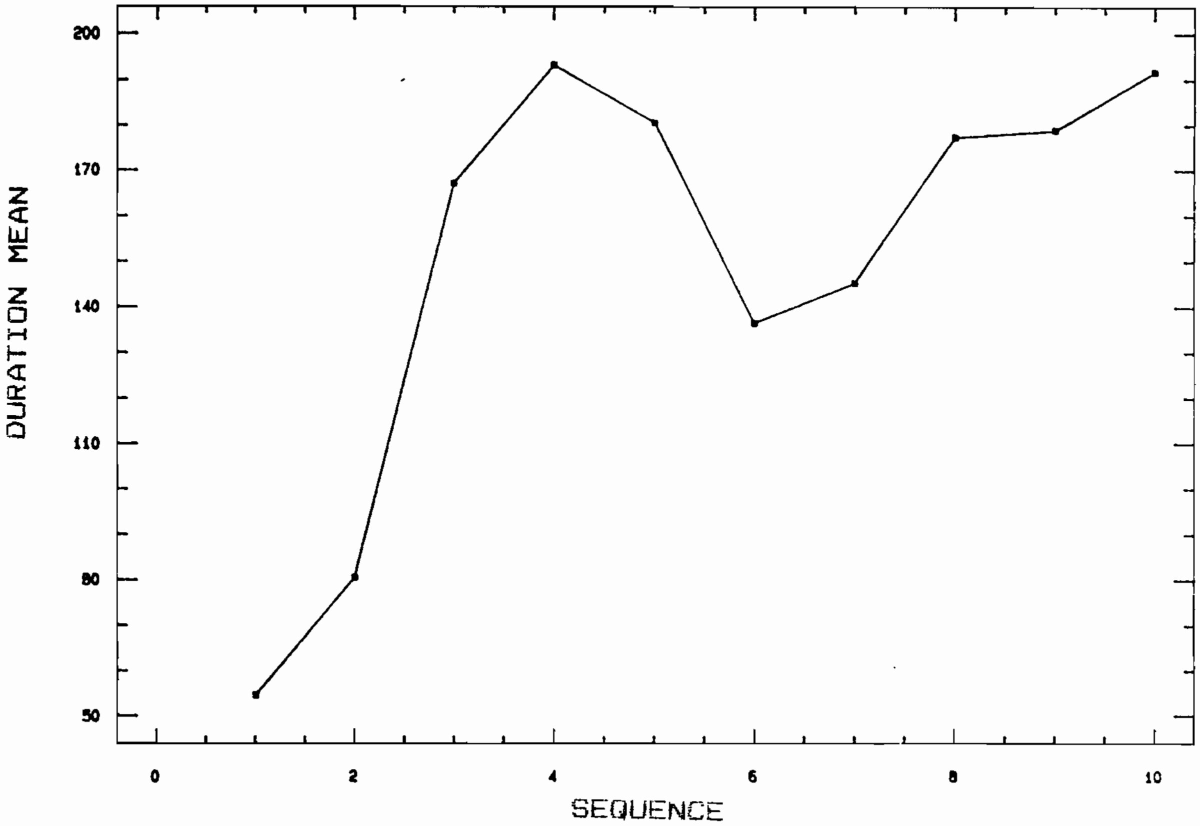


Fig 4. Evolution of the MILL structure duration during the experimental phasis in the periode of pertubation.

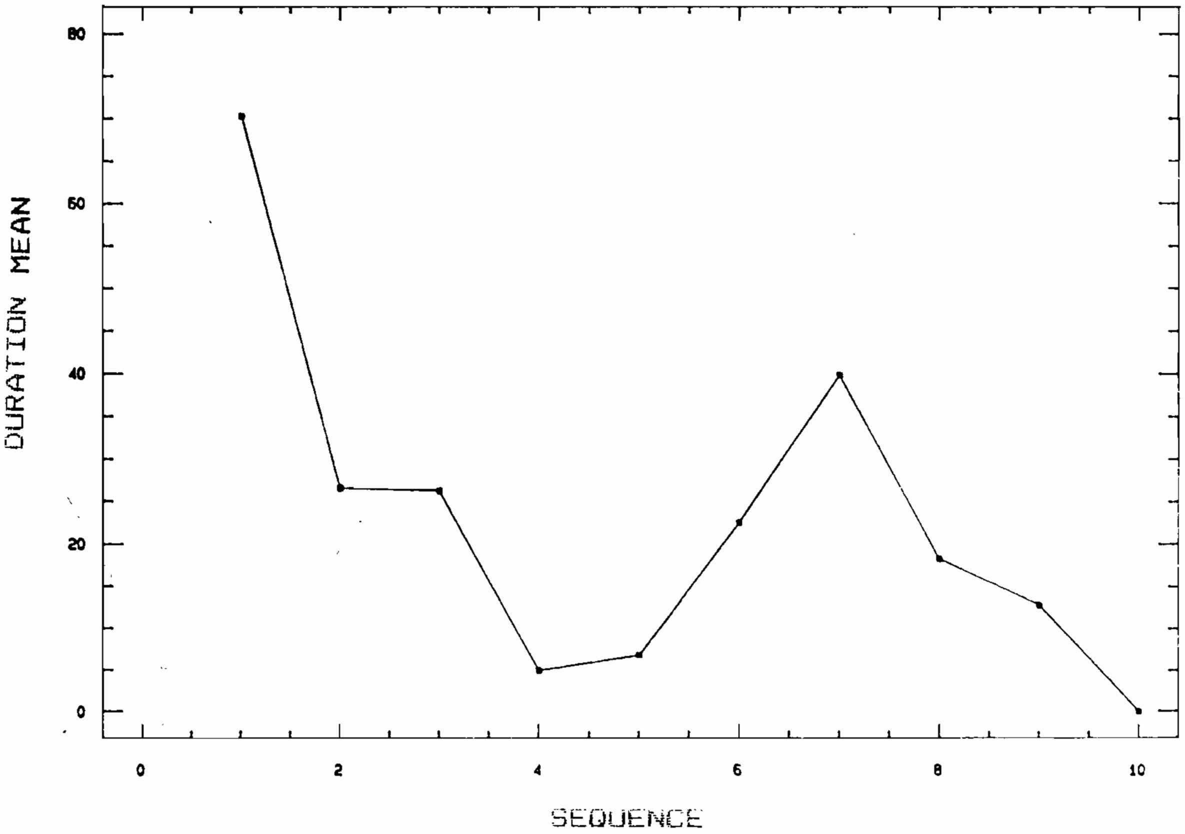


Fig 5. Evolution of the dispersion during the experimental phasis in the periode of pertubation.