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National Policy on Science Information*

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Before discussing the various aspects of our national policy on science information, it is perhaps relevant and useful for me to point out that, ever since the reorganization of the National Sience Council in 1967, we have placed a major emphasis on integrating science and technology into our overall national policy. This is a logical development of our rather rapid process of industrialization. It is also an important step in the search of relevancy on the part of our scientific community. Decision-makers at the highest level of our Government had occasion to consult two science advisers to the President of the United States; first with Dr. Donald Hornig in 1967, and then with Dr. Edward David in 1972. In this respect, I would to like to express our deep appreciation to our dear friend and colleague, Dr. Bruce Billings, who is here today and who in his four and one half year tenure in Taiwan, had been instrumental to whatever meaure of success we might have achieved in this direction.

As it will be true in any country, science and technology are structured in the Republic of China as a result of two determining factors: historical incidents on the one hand and conscious efforts on the other. Right after World War II, both higher education and major industrial facilities were in the public sector, rather than in the private sector, of the country. This has made it inevitable that research, academic and industrial, became primarily a governmental responsibility and function. This situation persists to this day, although in recent years we have adopted a strong policy to encourage both private industrial firms and private universities to spend more of their own resources on science and technology. We also feel quite strongly that, from this point on, they must substantially share in the national effort and help carry the ball.

So far our success in this direction has been meagre. The National Science Council, for instance, has been making annual estimates on our national investment in s ience and technology. And we have found that the amount from the private sector has been almost negligible. The lack of private incentive in the past could be attributed to a number of factors. First of all, most of our industrial firms were too small to embark on meaningful R and D work. They also lacked the minimum human and fiscal resources. The wind of change, however, is finally coming to Taiwan. A few industrial firms have grown considerably in the past decade, and we have also witnessed a new trend of corporate mergers. On human resources, Taiwan is also better off today than just a few years ago. Using the National Science Council again as an example, ten years ago we would consider the recruitment of a dozen Ph.D's in one year a humper crop. Last year, on our visiting professor program alone, we have induced over 250 Ph.D's to return from abroad, mostly from the United States. Between a quarter and a third of these young scientists and engineers can be expected to stay permanently, and our private industry can secure their services if it has serious programs for research and product development.

A second constraint on R and D activities in our private sector was the fact that our recent industrial growth depended too heavily on cheap labor. In the near future, we perhaps cannot phase out labor-intensive industry, but it is clear already that our labor will no longer be as low-priced as it used to be. More and more, capital intensive and technology-intensive industries are being introduced to Taiwan. This should provide added motivation for research and development.

Motivation for research and development is also conditioned by the pattern of competition. In the past, we competed only with exporters who had to pay higher wages than our wage scale. We now compete with a host of neighboring countries which have an edge on labor cost. In this category I can mention the Republic of Korea, the Philippines, Thailand, Malaysia and Indonesia.

I need hardly emphasize that it is vital for us to maintain a viable socio-economic system in Taiwan. It is therefore necessary for the industry in Taiwan to maintain a high degree of flexibility and to always keep a few jumps ahead in technology. For as long as I can foresee, this will perhaps be the most important motivation for our industries, public as well as private, to invest in research and development.

What the Government can do and should do to meeet these emerging needs is to help create a climate conducive to industrial research and agricultural development. This of course is a highly complicated undertaking, and I do not plan to go into details here. It suffices to point out that we need to work on both nontechnical aspects and technical aspects of the problem. In the former category, modifications of the tax laws and the strengthening of an ineffec-

(To continue on page 4)

**This is a statement made by Dr. Wu at the Workshop on Sicentific and Technical Information Needs and Resources in the Republic of China held at the U.S. National Academy of Sicences in Washington D. C. April 25-28 under the joint sponsorship of the U.S. and China Committees on Sicence Cooperation.*

A Feasibility Study on the Biological Control of Taiwan Mosquitoes

By Dr. Sidney C. Hsiao

(The research was part of Dr. Hsiao's assignments in the Republic of China as a long-term visiting scientist under the U.S.-ROC Cooperative Science Program. A professor of zoology at the University of Hawaii, Dr. Hsiao worked here at the National Taiwan University during 1971-72. —Ed.)

(*Continued from last issue*)

TABLE V

Premanence of induced sterility in *Culex pipiens fatigans*

Group	Days after irradiation	Mater pairs	Mean percent sterility	SS	Variance (s^2)	Standard deviation (s)	Standard error of means(sx)
I	7	17	99.17	33.5557	2.0972	1.4482	0.3512
II	14	16	98.45	333.5145	22.2343	4.7153	1.1788
III	21	14	79.74	15,501.5662	1,192.4282	34.5315	9.5773

Statistic analysis of the data by "anova" showed an aging effect, the percent sterility changed with delayed mating (see Table VI).

TABLE VI

Analysis of variance of percent sterility of irradiated mosquitoes aged for 1, 2, & 3 weeks before mating

Souce of Variation	D.F.	SS	MS	F
Among 3 groups	2	3,582.0455	1,791.0228	4.06*
Within the groups	44	15,868.6364	360.6508	
Total	46	10,450.6819		
*: P>0.05 $F_{.05(2,44)}$:3.21; $F_{.01(2,44)}$:5.12				

This ch nge was not noticeable between the first and second week, but after the second week it was obvious as shown in Table VII.

TABLE VII

Analysis of variance of percent sterility between weeks of aging of radiosterilized imagoes

	Source of Variation	DF	SS	MS	F	P	Note
Comparison of 1st & 2nd week	Among groups 1 & 2	1	4.3588	4.3588	0.369	>.50	$F_{.5(1,31)}$:.466
	Within groups	31	367.0702	11.8410			
	Total	32	371.4290				
Comparison 2nd & 3rd week	Among groups 2 & 3	1	2,611.9163	2,611.9163	4.618	>.05	$F_{.05(1,28)}$:4.20
	Within groups	28	12,835.0807	565.5385			
	Total	29	18,446.9970				
Comparing 1st & 3rd week	Among groups 1 & 3	1	2,898.5422	2,898.5422	5.410	>.05	$F_{.05(1,29)}$:4.18
	Within groups	29	15,535.1219	535.6938			$F_{.025(1,29)}$:5.59
	Total	30	18,433.6641				

In a duplicate experiment these data were obtained for the first two week post-irradiation:

Mated pairs	20	6
Range of percent sterility	63.84-100%	97.86-100%
Mean percent sterility	96.27	99.35
Standard Deviation	77.4884	3.5912
Standard Error of Mean	1.968	0.245

When the relative magnitudes of the variance component and error variance were expressed as a percentage of their sum the proportion of variation among groups, i.e., from week to week, were:

2nd to 3rd week : 0.2011
1st to 3rd week : 0.9196
1st to 2nd week : 0.3986

The range of percent sterility at the end of the first week was 95.15 to 100 percent among 17 mated pairs, and at the end of the second week, 81.25 to 100 percent, among 16 mated pairs. These data supported the dea hat no loss of sperm sterility took place for two weeks.

These observations support the conclusion relative to the permanence of induced sexual sterililty that there was no loss in sperm sterility during the first week or two after radio-sterilization, and some individuals lost their sterility during the third week.

Longevity of Radiosterilized House Mosquitoes

Studies were made to estimate the effect of radiosterilization of pupae on the longevity of the eclosed adults. Pupal were irradiated with Co-60 in 4 groups by exposure to 7 to 13 Kr in steps of 2 Kr. From each group 100 imagoes were taken at random and held in a cage isolated from females, 100 were allowed to cohabit with an equal number of virgin females. Each cage was examined daily for mortality. A control was set up for each experiment. The mortalities of irradiated mosquitoes are shown in Figures 3 to 5.

(1) Figure 3 shows the cumluative percent mortality of treated males isolated from females for 36 days. There is no significant difference in mortality between males exposed to different levels of gamma radiations, nor between irradiated males and unirradiated control. Cumulative mortality reached 10 percent between the 12th-14th

day or 0.77 percent died per day during the first two weeks post-irradiation irrespective of the exposure dosage. The 50 percent survival time can be seen in column 2 of Table IX.

TABLE VIII

Analysis of variance of data from duplicate experiment

Source of variation	D.F.	SS	MS	F	P
Amog groups	1	48.7501	48.7501	.795	.25-.50
Within groups	24	1470.8719	61.2863		
Total	25	1519.6220			

TABLE IX

Mortality of radiosterilized males isolated from females

Dose in Kr	Post-irradiation days with 50% surviving	Cumulative mortality on 36th day
13	28	58%
11	30	59
9	25	79
8	25.5	77
0	24	74 (control)
Average	26.5	69.4%

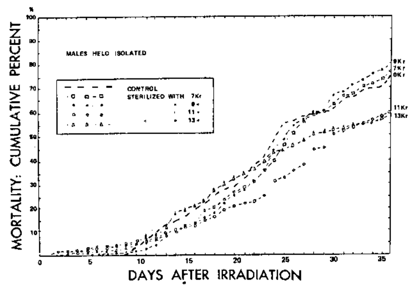


Fig. 3 Mortality of radiosterilized males kept in isolation from females. Percent cumulative mortality plotted against days after irradiation.

On the average, 50 percent of the treated males survived for 26.5 days. Half of the males exposed to the high doses, 11 and 13 Kr, survived for 28 to 30 days. The control did not survive longer than the treated males. The cumulative percent mortality at the end of the observation period is given for each dosage in the last column of Table IX. There was no correlation between dosage level and mortality, and, on the average, about 30 percent of the mosquitoes survived for 36 days.

(2) When cohabited with females, Figure 4, 10 percent of the males died during the 7th to 13th day post-irradiation. One half of the males exposed to 11 Kr and of the control died at the end of the third week, their cumulative mortality at the end of the experiment period was 83 and 69 percent respectively. At least 50 percent of the males exposed to the other doses of radiations survived to the 36th day. The dose-survival relationship after 5 weeks was

Dose in Kr	13	11	9	7	0(control)
Survival on 36th day, %	56	17	50	31	

There did not seem to be a correlation between exposure dosage and longevity.

(3) As to be expected, the mortality rates of females cohabited with radiosterilized males were not different from that of the females caged with normal males. The cumulative mortality curve of females cohabited with radiosterilized males is similar to that of the control. In all the experiment 2/3 of all the females were alive on the 36th day. The mortalin rates of the females from the different cages were similar.

Conclusions

1. It is feasible to maintain a laboratory colony of the most abundant species of Taiwan mosquito, *Culex pipiens fatigans* and rear large numbers for experimental use.

2. Irradiation of male mosquitoes can be most conveniently done at the pupal stage with a Cobalt-60 source. The induced percent sexual sterility showed a linear regression on the logarithm of the dosage used. A sterility above 90 percent could be obtained with 9 Kr of gamma radiation.

3. Newly eclosed imagoes reacted differently toward gamma radiations. They showed three regression lines in their dose-sterility curve. The slope of the regression lines changed at 6 and 9 Kr. From 1 to 6 Kr there was a 14 percent increase in sterility for each Kr of exposure dosage.

4. In bench-top experiments, after exposure to 7 or 9 Kr the sterilized males competed successfully with wild males for available females.

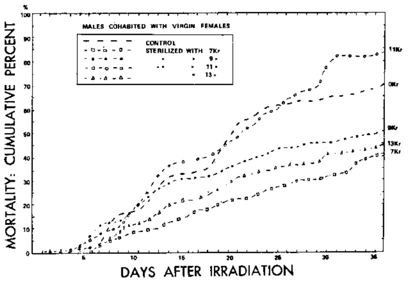


Fig. 4 Mortality or radiosterilized males cohabited with virgin females. Precent cumulative mortality plotted against days after irradiation.

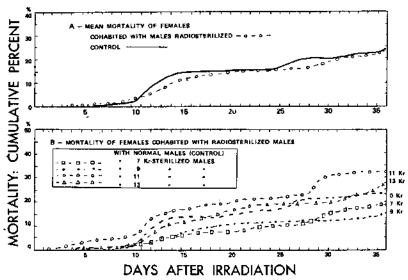


Fig. 5 Mortality of females cohabited with radiosterilized males. Precent cumulative mortality plotted against time.

The best ratio of sterile males: normal males:virgin females was 8:1:1. Males exposed to 11 Kr did not compete with normal males as effectively as those treated with lower levels of gamma radiations. Additional field cage tests on mating competitiveness of radiosterilized males are highly desirable.

5. Sperm sterility induced by gamma radiation lasted for at least two weeks. During the third week post-irradiation 1/5th of the treated males may regain fertility.

6. Gamma radiations used in these experiments did not shorten the life of the treated mosquitoes when kept isolated or allowed to cohablt with virgin females. When kept isolated 20 to 40 percent survived for as long as five weeks. During the first two weeks post-irradiation when the sperm sterility was unchanged the mortality was 10 percent among isolated males irrespective of their exposure dosages.

7. From these observations on percent of induced sterility, mating competitiveness, permanence of sperm sterility, and post-irradiation longevity we can conclude that it is feasible to employ the male release technique for the biological control of Taiwan mosquitoes if the male pupae were exposed to 7-9 Kr of gamma radiation and used within two weeks after irradiation.

National Policy on Science Information

(*Continued from page 1*)

tual patent system are now in order. In the latter category, we must step up our efforts in matters such as management training, metrological and standards services, and, last but not least, a truly useful science information network.

In 1968, the National Science Council set up a Scientific Documentation and Instrumentation Center on a modest scale. Witth the above considerations in mind, the National Science Council decided to make greater efforts in the two areas establishing the scientific documentation and the scientific instrumentation part as independent units. A new building for the Scientific Documentation Center was completed in March 1973. We made this move as we realized that investment in science information is in the nature of an investment in the infrastructure of technology. We also realize that the resources at the disposal of the National Science Council are meagre, and we have no intention to do the whole job. Nevertheless, we are determined to make a start, in the hope that we may establish a pattern of effective information collection, retrieval and dissemination.

The budget of the National Science Council (which is known as the Science Fund) at present represents only about 15% of the national spending on science and technology. As the Science Fund is the major source of support in our universities, we can only allocate a limited amount for applied research. The major responsibility for funding applied research in industry and agriculture rests with other government departments, including the Ministry of Economic Affairs, the Ministry of Communications, the Ministry of Defense and the Joint Commission on Rural Reconstruction. What the National Science Council chooses to do in applied research is to build up university-industry interaction, and to support exploratory projects with seed money. These fiscal facts point clearly to a limited role for the Scientific Documentation Center (SDC).

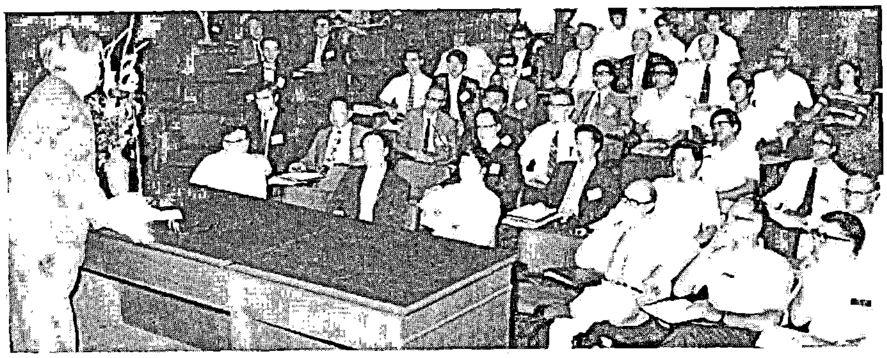
The SDC will not be the sole source for scientific information, but should strive to be a service-oriented clearance house, and should aim to be the coordinator of a national effort. It is not to replace the existing facilities of scientific information, nor to act merely as a supplementary channel. On the contrary, the SDC's mission is to provide several crucial missing links in our scientific and technological community.

One of the grave defects of our scientific community is the lack of communication. Research scientists know relatively little about what have been done, or are being done in related fields, and therefore cannot build on where others have left off. In more extreme cases, there are researchers whose knowledge of what goes on in his own field and in his own institution is only fragmentary. This situation gives rise to much waste of time and money. To improve communication among our researchers, we have been encouraging inter-university programs and topical workshops. The Scientific Documentation Center should be able to make a substantial impact in this respect. It should not only periodically take inventory of our R and D efforts, keep track of who is doing what, but also to act as a referral agency which can steer inquiries to proper sources. In this respect I should particularly stress the importance of building up a useful file on our scientific manpower, including the many thousands of Chinese scientists who work abroad but may be induced to participate in our science development work in a number of capacities.

Another weakness of our research libraries is that there is a tendency of acquisition for the sake of acquisition. Not enough attention has been paid to, I must confess, the real needs of research. In this respect we very much hope the SDC can be made into a model of responsiveness. Our goal is not to process scientific information per se, but to channel relevant information to serve relevant purposes.

In a limited way, the SDC should develop the capability of providing contract services. What is important is not to ask the Scientific Documentation Center to provide the information needs of our industry in total, but to ask it to set up an efficient pattern and to demonstrate how this should be done. Given a certain level of knowledgeability in the processing of technological information, the SDC should be in a position to assist industry in establishing their own information mechanism.

It is indeed most fortunate that the Joint Committee for Sino-American Science Cooperation should sponsor this workshop at this time. We know there are problems of greatest complexity to be resolved if we are to achieve our goals, and we appreciate this opportunity which allows us to take advantage of the wisdom and experience of our American friends. Some of my colleagues have made tentative plans to implement a more efficient system of science information in Taiwan, and they will present their ideas for comment and discussion. I am particularly grateful to Dr. Robert Hayes, my co-chairman of this workshop, for he had taken the trouble to visit Taiwan for a month last year, and his survey report is regarded by us as a fountainhead of constructive ideas. While we have definite goals and a firm commitment to improve science information services, let me stress that we come to this meeting with an open mind, as well as a strong conviction that we shall benefit from your remarks, observations and suggestions. Thank you.



Dr. Ta-you Wu, chairman of the National Science Council, addresses the Sino-U.S. Seminar on Seismology held in Taipei May 7-12 (Science Bulletin Vol. 5 No. 5).

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