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THE PIONEERING WOMEN IN THE SPANISH MARINE AND FRESHWATER SCIENTIFIC RESEARCH EFFORT (1923-1969)

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RESUMEN

Durante el periodo 1923–1969, 20 investigadoras [11 del Instituto Español de Oceanografía (IEO) y 9 del Consejo Superior de Investigaciones Científicas (CSIC)] publicaron en las revistas científicas de ambas instituciones, solas o en colaboración, 65 artículos relativos a las ciencias marinas y del agua dulce (oceanografía, plancton, biología pesquera, bromatología, algología, etc.).

El entorno causal de la actividad científica estudiada se ha dividido cronológicamente en dos periodos: 1923–1945 (únicamente con revistas del IEO) y 1946–1969, desde las primeras producciones escritas del CSIC. Se ha procedido a la revisión y cuantificación de los artículos publicados por todas las investigadoras en las revistas de ambas instituciones, clasificándolos temáticamente y valorándolos. El estudio comparado realizado, ha mostrado un significativo descenso generalizado en el nº de artículos e investigadoras del IEO durante los años sesenta, coincidiendo con la "entrada en escena de las investigadoras del Instituto de Investigaciones Pesqueras (IIP)". Se complementa el estudio con el análisis e interpretación de las variaciones inter- e intra-institucionales, principalmente a partir del conjunto de las citas bibliográficas extraídas de la base de datos internacional SCI (Science Citation Index).

Palabras clave: *Mujeres y Ciencia, Oceanografía, Historiometría, Bibliometría, España, IEO, CSIC, Siglo XX.*

ABSTRACT

Over the 1923-1969 period a total 20 female scientific researchers (eleven from the Spanish Institute of Oceanography (IEO) and nine from the Higher Council for Scientific Research (CSIC) had 65 articles published in the journals of these two government organisations. The articles, relating to marine and freshwater sciences, which were written solely by them or in collaboration, deal with oceanography, plankton, algology, food-fish biology, food science, etc.

The time-span of this scientific activity is being split into two sub-periods, viz.: 1923-1945 (articles solely in IEO's journals) and 1946-1969 (starting off with the first relevant CSIC's publications). We are quantifying, sorting by subjects, reviewing and evaluating the articles published in the journals of both organisations. The accomplished study shows a meaningful, generalised comparative decrease in the number of IEO's female researchers and articles in the 1960s, coincidental with the "coming into the picture" of their counterparts from the Institute for Fishery Research (IIP) under the CSIC. The study is complemented with an analysis and interpretation of the inter- and intra-organisational variations, chiefly on the basis of the comprehensive biographic references extracted from the Science Citation Index or SCI (international database).

Keywords: *Women and Science, Oceanography, Historiometrics, Bibliometrics, Spain, IEO, CSIC, 20th Century.*

1. Introduction: the organisational framework

In this study we are primarily comparing the research activities of the organisations formed by this country's forerunners of the modern aquatic sciences, viz.: Odón De Buen y del

Cos (1863-1945), founder of the Spanish Institute of Oceanography (IEO) in 1914, and Francisco Garcia del Cid (1897-1965), from the Institute for Applied Biology (IBA) and the Institute for Fishery Research (IIP)¹, both under the CSIC.

The outset of the CSIC's organisational participation in freshwater science can be dated from 1943, with the foundation of IBA, and that in marine science from 1946, with the appearance of the first article on marine biology published in IBA's journal, and from 1948 (when an IBA member appeared for the first time on a list of Spanish experts in fishery research²). Thereafter a Marine Biology Section was created in IBA (1949), which was considerably developed until it became an independent organisation, as the IIP, in 1951. In the following year, IIP extended its research activity to the Atlantic Ocean with the opening of a laboratory at Vigo and, subsequently, with a further laboratory at Cádiz (1955). IIP became consolidated within the 1955-1965³ decade, which event having coincided with the creation, in Madrid, of a Consultative Board on Scientific Fishery Research in the former year⁴. This body served to co-ordinate the studies in the matter carried on by the Directorate-General for Sea Fishing (DGPM), IEO and IIP, by holding quarterly meetings with the respective directors and their professional advisers⁵.

Organisational collaboration among researchers occurred from the outset, such as that between the director of IEO's Laboratory in Majorca (M. Massuti), who authored articles for the journal [Publications of the Institute for Applied Biology] and was one of the lecturers at a course entitled

[Introduction to Fishery Research] (Blanes, 1949). Researchers from both organisations happened to come together at the four

[Meetings on Productivity and Fisheries] held within the 1955-1965 decade. Students on scholarships and researchers from IIP completed their research careers at IEO, and vice versa (e.g., Buenaventura Andreu, one of the IIP founders, started out as a student on a scholarship from IEO- Santander).

2. Material and methods

We are addressing a study of IEO's and CSIC's female researchers in several stages.

2.1. Identification of the Female Researchers from both Organisations

We first made an exhaustive review of the articles on marine⁶ and freshwater⁷ sciences as published in the journals of the respective organisations. We are including the research assistant Josefa Sanz Echevarria (1889-1952) who, without holding a university degree, succeeded in having numerous studies published in different evaluated scientific journals⁸. This review of the

¹ Three pioneering females assigned to the Institute for Edaphology and Plant Physiology and to the National Natural Science Museum, both under CSIC, did research work during this period, as mentioned below.

² International Council for the Exploration of the Sea (ICES). Report for October 1948 includes a list of Spanish experts who were members of IEO (35), the Directorate-General for Sea Fishing (4), the Guipuzcoan Oceanographic Society and the directors of the Naval Institute of Hydrography and of IBA. ["Del Cid, F.G.", without specifying their specialities]. ICES, 1949, p. 27.

³ IIP's professional staff doubled within the 1952-1965 thirteen-year period, reaching 50 researchers. [GUERRA and PREGO, 2003, pp. 164-165].

⁴ Two years previously, IEO requested the creation of such a body [IEO, 1953, p. 46] when it called for the creation of a Council on Fishing Industry Planning to co-ordinate the action of the existing organisations and to issue general guidelines in fishing matters.

⁵ [GUERRA and PREGO, 2003, pp 120-121].

⁶ Separately for each organisation: IEO [(1923), (1927-1947), (1948-1966), (1957-1969) and (1956)]; and CSIC [(1946-1968)]

⁷ From the journal (1946-1968).

⁸ She was the first Spanish professional assistant in marine science research. All her articles are focused on otoliths (fish ear-bones whereon the growth rings of a specimen are marked). She began her studies at the Santander Marine Biology Station (1907-1915), prior to being transferred to IEO, continuing such studies at the National Natural

articles is completed with an overall analysis of the aggregate bibliographic citations extracted from the Science Citation Index (SCI, international database) in Web of Knowledge (WOK, from ISI Thompson©).

2.2. Time Adjustments

Having verified that both organisations have different time-wise plans, we are applying our analysis on three different scales, as shown in Table I, viz.: (1) The global period (years 1923-1969) for both organisations (considering all the articles published in IEO's and CSIC's journals). (2) A 1923-1945 sub-period (solely for marine science), which is characterised by the absence of documents signed by females within the aggregate IEO scientific output as registered in the SCI database for those years (77 articles). And (3) a 1946-1960 sub-period (marine and freshwater sciences).

Table I. Quantification of Articles and Authoresses (sub-periods and global), based on a count of the articles appearing in their organisational journals.

PERIOD	1923-1945	1946-1969	1923-1969
IEO			
Articles	14	32	= 46
(%)	(93.3 %)	(64 %)	(71 %)
Authoresses	6	9 (5 new)	11
CSIC			
Articles (%)	1 (6.7 %)	18 (36 %)	= 19 (29 %)
Authoresses	1	9 (8 new)	= 9
TOTAL ARTICLES	15 articles	50 articles	= 65 articles
TOTAL AUTHORESSES	7	18 (13 new)	20

2.3. Historiometrics

In accordance with the identification of "a scientific career" as made by NOWAKOWSKA [1975, p. 296]⁹, the general plan of an organisation where each female scientist develops her career will determine her personal time-wise horizon. To that end, we are describing the comparable scientific authorship patterns in each organisation for the 1946-1969 sub-period, i.e. from the time when CSIC's females in the Aquatic Sciences area started having articles published. We are analysing the inter- and intra-organisational variations, chiefly from the aggregate citations extracted from the SCI database, with the exception of three authoresses,

Science Museum (MNCN) under CSIC. Within the 1943-1950 period, this authoress collaborated sporadically with IEO (Fishes in the Sahara) and had articles published in its journals. The SCI collection covers several of her articles appearing in another publication unconnected with her organisations (See Note 10). In view of the foregoing, we are here associating her scientific production with that of CSIC, while preserving her organisational identity and topic area.

⁹ Identified with an eventful process, such as solving a research problem, obtaining a particular scientific degree, being nominated for a given job, receiving a scientific award, being a member of the Editorial Board of a journal or a member of a scientific committee, acting as a judge on doctoral dissertations, participating in a scientific congress, etc.

viz.: Josefa Sanz Echevarría (CSIC)¹⁰, Dominica Montequí (IEO) and Josefina Pérez Mateos (CSIC)¹¹.

3. Prior results

3.1. Authoresses from IEO

We have identified 12 female researchers from this organisation. Prior to 1936 we have found only four, who were attendees at a course given by Dr. Adrien Robert General Secretary of the Société Zoologique de France (IEO, April 1925. See Fig. 1), viz.: Emma Bardán Mateu (1898-1992), Mercedes García López (1904-1990), Gimena Quirós Fernández-Tello (fl. 1922-1931) and María Encarnación Sánchez Herrero (fl. 1932-1933). In the post-Civil War period, specifically during the 1941-1951 decade, accession to IEO was consolidated with the admittance of four full-tenured female researchers, who were assigned to newly-created sections, viz.: Applied Chemistry Department (María Jesús del Val and María Dolores García Pineda); Physicochemical Department (María Martín Retortillo) and Physical Oceanography Department (María Luisa González Sabariegos), plus as many other associated researchers (Teresa Valls, María Carmen Méndez Isla, Dominica Montequí and Ángeles Alvariño). During this decade several of those young oceanographers implemented novel lines of research, such as food biotechnology and development of new applications for, and treatment of, fish by-products, and algae capable of being exploited by the processing industry.



Fig. 1. Course given by Dr. Adrien Robert (IEO-Madrid, April 1925) with the participation of four IEO's female oceanographers (From left to right: Encarnación Sánchez, Mercedes García, Emma Bardán and Gimena Quirós).

3.2. Authoresses from CSIC (IBA, IIP and others)

The presence of the two first CSIC female researchers in organisational journals occurred in the mid-1940s, with Josefa Sanz Echeverría¹² (MNCN) respecting marine science, and with Montserrat Bassedas (IBA) respecting freshwater science. In the 1950s, Josefina Pérez Mateos and Julia María González Peña, sedimentologists (both from the Institute for Edaphology and Plant Physiology or IEFV) and Dolores Selga (IBA), a zoologist, had articles published.

¹⁰ The SCI collection covers three of her articles published in the *Boletín de la Real Sociedad Española de Historia Natural* (for the years 1931, 1941 and 1949).

¹¹ Respecting the latter two female researchers, the six sources cited in SCI (five journals and the minutes of a meeting) are also publications unconnected with their Institutes. In this specific instance, we shall only analyse the citations by adopting a prosopographic approach [LÓPEZ PIÑERO y TERRADA, 1993, p. 16] to the SCI database, without studying or evaluating the agedness of the references or the subject content of the six items.

¹² See Notes 8 and 10.

Finally, with the creation of IIP, María López Capont, Josefina Castellví, Dolores Blasco and Tecla Riera signed up from 1958. Plankton, primary production, bacteriology and parasitology were the areas for development in their individual scientific careers.

3.3. The First Generations of Female Oceanographers (IEO and IIP)

1ST GENERATION (1925, IEO-Madrid, Fig. 1): Encarnación Sánchez (Madrid, 1903-1934?), Mercedes García¹³ (1904-1990), Gimena Quirós (fl. 1922-1931) and Emma Bardán (Madrid, 1898-1992). The last-named carried on her entire career at IEO (1925-1962). She participated in oceanographic surveys (1926 and 1928) and in international congresses [ICES, 1949], and had articles published during the 1927-1952 period. She was the most prolific authoress and had the broadest interdisciplinary education of the threesome. After being transferred to IEO in Madrid, she was an anonymous contributor to the articles of other authors, who appreciated her collaboration.

2ND GENERATION. Two were the most representative female researchers, who were born in one same year and who left IEO 40 years later. The first of the two was the daughter of an Admiral and the second was the daughter of a physician. The former, María Dolores García Pineda (Cádiz, 1916), who had Ph degrees in Pharmacy and in Biochemistry, worked for IEO (1944-1956) and for several foreign Universities and Laboratories, and finally for the Spanish Nuclear Energy Board (during 25 years). The latter, Ángeles Alvariño (Ferrol, 1916 - California, 2005), was a researcher with IEO and DGPM within the 1951-1956 period. She experienced her first survey in 1953 (was the first female scientist on a British oceanographic ship), continued her professional career at prestigious U.S. oceanographic organisations and participated in congresses even after her retirement.

3RD GENERATION. This generation is represented by Josefina Castellví (Barcelona, 1935). In the 1960s she became the first female researcher at CSIC. She was directress of the Institute for Marine Science, Barcelona (1994-1995), participated in 36 oceanographic surveys, was the first Spanish female scientist to do research work in the Antarctica and attended her first international congress (CIESMM) in 1962.

In Fig. 2 we are showing the time-wise evolution (number of authoresses and of published articles) for the aggregate female researchers in both organisations within the overall period (1923-1969) under consideration. The intellectual development of these Spanish female scientists sustained a strict correspondence with the vacuum caused by the Civil War (1936-1939), this being an interval which we are accordingly dismissing here for comparative purposes. The levels reached 10 years earlier (as to number of authoresses and of articles) were not surpassed until the 1940-1945 quinquennium.

¹³ A Licentiate in Natural Science, in 1926 she embarked with Emma Bardán on the sailing ship *Príncipe Alberto de Mónaco* belonging to the Oceanographic Laboratory at Málaga. Both of them became the first Spanish female researchers to participate in an oceanographic survey. This is the only instance where we have been unable to trace any published article of an IEO female researcher, no doubt because of the fact that she was assigned to the Central Laboratories to discharge managerial and co-ordination duties. This was also the case with her colleagues Gimena Quirós and Emma Bardán, who did not have any articles published when they were assigned to IEO in Madrid.

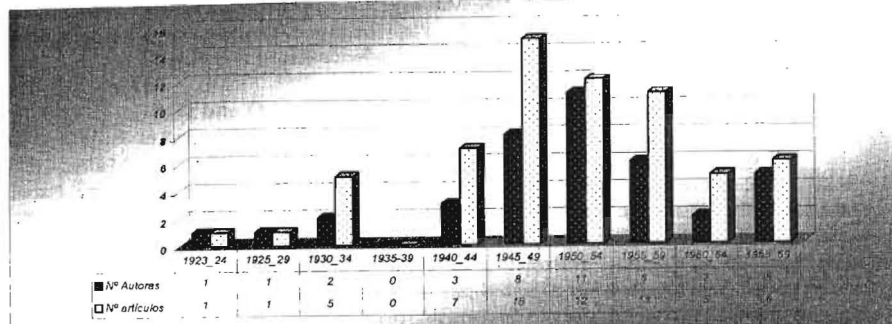


Fig. 2. Global time-wise evolution (by quinquenniums) of the number of authoresses ("Autoras") as compared with the number of published articles ("Articulos") from the female researchers of both organisations: IEO (1923-1969) and CSIC (1946-1969). (Spanish civil war: 1936-39)

3.4. Inter-organisational Relationship of These Pioneering Females

We have ascertained that in the 1943-1958 fifteen-year period three CSIC female researchers accepted an offer from IEO to analyse samples from its surveys and had five articles published in its *Boletín*¹⁴. This situation reflects a timely but 'forced' organisational co-operation because of a lack of particular specialists (specifically in fish otoliths and marine sediments) in one of the organisations. By including these female researchers in the computation we arrive at an absolute total 16 authoresses, which represents 18 per cent of the aggregate scientific community from both organisations (IEO + CSIC) having articles published in these journals. We shall expatiate on other aspects of this inter-organisational relationship below.

4. Historiometrics: measurable aspects of the comparative scientific careers in both organisations (1946-1969).

4.1. Organisational Authoresses to Authors Ratio and Productivity of the Female Researchers

At IEO females (♀♀), as stated above, represent 20.4 % of the scientific community having articles published (i.e., 11 ♀♀/ 54 ♂♂). This is a value higher than that (13.8 %, 5 ♀♀/ 36 ♂♂) found for CSIC's publications. We have verified that there is a higher time-wise continuity in the presence of IEO authoresses until 1962, while the findings of the CSIC authoresses are grouped together within the initial and the final years of the sub-period (Fig. 3). The former authoresses, who focus solely on oceanography, do not numerically constitute a demographic nucleus, being therefore entitled to the 'taxonomic' rank of 'continuants' [PRICE, 1986, pp. 206-226], as they appear in succeeding yearly publications.

¹⁴ These authoresses were the already-mentioned Josefina Sanz Echeverría from MNCN (1943-1950) and the two from the Institute of Edaphology, viz.: Josefina Pérez Mateos (1952-1958) and Julia María González Peña (1958).

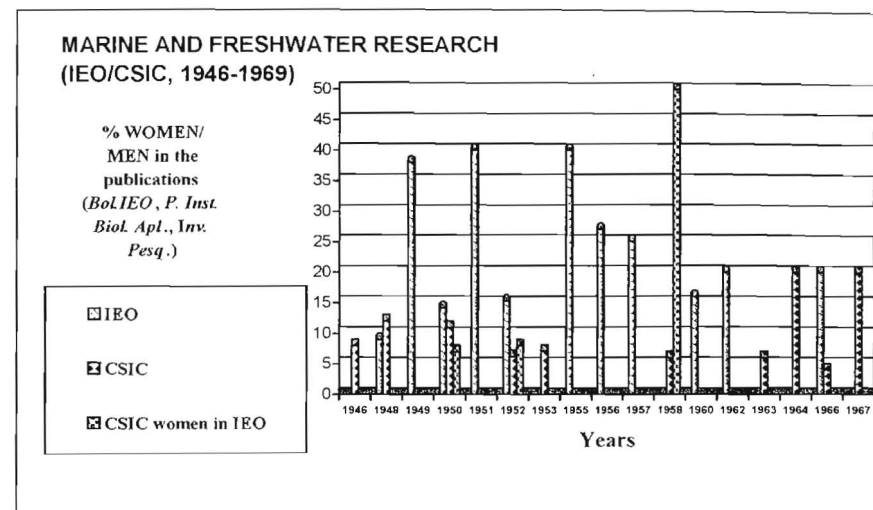


Fig. 3. Females/males in the authorship of published articles on marine and freshwater sciences within the 1946-1969 period, IEO versus CSIC.

Indeed, 20 % of the 133 articles published in the IEO's *Boletín* during this sub-period represents the participation of females, but we observe a yearly decrease in the rate of their published articles. However, in all the years within the 1948-1958 decade there is continuity in the number of published research findings by IEO's female scientists. Subsequently, this occurred in alternate years until 1962. And in the last eight years of the sub-period, it occurred precisely in 1966. The presence of gender dynamics in the 1960s is, in the absence of accessions, which are minimal as regards IEO. Such situation may be accounted for by either conclusion of a completed working life on the research front or the current unacceptance by youths of work commitments for only one or several short time-spans.

In the case of CSIC, we are witnessing the initial phases of an accumulated scientific authority of two (out of the nine) female leaders in the current research in marine science. As in every internal, selected imbalance process, the system keeps these scientists in positions "from which they can grow". [NOWAKOWSKA, 1977, p. 326]. The aggregate authoresses in marine and freshwater sciences do not represent more than 10 % of the articles published in CSIC's journals during the years in which they were active writers. For another thing, the events regarding freshwater research took place during the 1946-1950 four-year period, most of the authoresses concerned having worked solely, without collaborators, in 80 % of the work projects involved. In oceanography, however, which was a consequence of a subsequent seventeen-year cycle (1950-1967), these female researchers had articles published in seven of those years. Particularly two of these authoresses (Dolores Blasco and Josefina Castellvi), who were confirmed participants on the research front in the seven years, were to become highly prolific writers.

An inter-organisational comparison between the female authoresses shows, on an equal footing number-wise (9), that those of IEO signed 64 per cent of the aggregate articles by the authoresses in both organisations (Table I). Likewise, an examination of the SCI database confirms the higher average productivity (twofold: 4 to 2) of the IEO authoresses versus that of their CSIC colleagues, but a similar number of citations for both groups remains stable (Table II).

Table II. Authoresses from Both Organisations and their Recorded Citations for the 1946-1969 period, as Taken from the SCI Database.

SCI PERIOD (1946-1969)	IEO AUTHORESSSES (9) [mean value]	CSIC AUTHORESSSES (9) [mean value]	TOTAL
Articles	36 [4]	18 [2]	54
Citations	58 [6.4]	70 [7.7]	128

N.B.: Extra-organisational journals are being included here, hence the difference in the number of articles as given in Table I.

4.2. Marine Research versus Freshwater Research

Freshwater research is solely a concern of CSIC and applies only to the articles published by IBA in its journal (*Publicaciones del Instituto de Biología Aplicada*) from 1946. The participation of female oceanographers in that organisation represents 9 per cent of the aggregate authors in the (non-recurring) years in which they had articles published. For another thing, the oceanographic participation of the CSIC females (1950-1967) does not respond to the customary regularity concept because there are various publication gaps (See Fig. 3). They represent seven per cent of the total scientific authorship in CSIC's oceanography (the count being restricted to authors in the years when there was a presence by gender).

4.3. IEO and CSIC: Organisational Recognition (Table III)

The organisational identity, by reason of the activities of these female oceanographers, is concentrated in the case of CSIC but is scattered as regards the IEO data. Such a configuration, which is accounted for by the correlation coefficient, shows the value $r = 0.71$ ($t = 6.53$; + 25 degrees of freedom), which suggests that the inconsistency does not appear as regards the number of observations. The generated image is, therefore, comparable as regards the context of applicability of the methods and results being set forth here. The length of recognitions is greater in the case of IEO, while in the case of CSIC the context sticks closer to the general plan of the organisation generating the recognitions. Indeed, as suggested by the variance value ($\sigma^2 = 18.41$), recognition of the authoresses is much more likely in the CSIC own organisation than in IEO ($\sigma^2 = 1.25$). In fact, the SCI database does not recognise any citation exercise received by the IEO female oceanographers from their own organisation. There is only a brief recognition, of a self-referential nature rated at 92 %, in the bibliographical listings quoted in its own articles.

Table III. Organisational Recognition of the Female Researchers' Work

ASPECT	IEO	CSIC
Significance of the number of remarks <i>Correlation coefficient</i>	$r = 0.71$	
Recognition by the own organisation <i>Variance</i>	$\sigma^2 = 1.25$	$\sigma^2 = 18.41$

4.4. National / International Returns (Table IV)

IEO's scientific output goes to 21 countries, whereas that of CSIC goes to 10 countries. Different statistically meaningful averages (2.3 for IEO and 5.8 for CSIC) identify both groups of authoresses. However, the harmonic means are not too different (-1.41 for IEO and -1.23 for

CSIC). For that reason, we could conclude that, although the use of the scientific findings is twice as concentrated in Spain in the case of CSIC, the predictions from such findings address similar creativity criteria [ZUSNE, 1976].

Table IV. Destination of, and Creativity in, the Authoresses Scientific Output

Organisation	Countries	Average Destination (X)	Creativity (Harmonic mean)
IEO	21	2.3	1.41
CSIC	10	5.8	1.23

4.5. Topical Similarity (Table V)

On the assumption that we have no *a priori* information available on the process that generated the data, we are employing the non-parametric Mann-Whitney test in order to consider whether the similarity or the difference in the topical content of the articles by the female researchers in marine and freshwater sciences from the two organisations can be attributed to chance.

We observe one single condition within the 1944-1969 period, viz.: distribution of the production of citations (as extracted from the SCI database) by ranking categories and directed towards the articles by authoresses from IEO and CSIC. Having at 5 % ($51, + \infty$) the acceptance domain for the test, a $U = 73$ statistical value is obtained. Accordingly, we have to accept from the topical viewpoint that the scientific output of both organisations does not differ, in a meaningful statistical manner, as to the contribution of both female researchers.

Table V. Application of the Mann-Whitney Test to Topical Similarity Between the Scientific Outputs of the IEO's and CSIC's Female Authoresses.

Scientific outputs of the female researchers	Statistical Value	U	Acceptance domain	Is there a meaningful statistical differential in research content?
CSIC <i>versus</i> IEO	73		(51, + ∞)	Content does not differ

4.6. Communication and Collaboration Images (Table VI)

In this subsection we shall look into the degree of communication between the authoresses of both organisations by examining the role that information and experience play in both directions, taking into account that many of the communication difficulties are reflected, and perhaps magnified, in the literature [HOADLEY & KETTENRING, 1990]. These relations are illustrated by indicating the reference sources of the other organisation included in the articles under review.

The image of the CSIC's publications depends much on its flagship journal (*Investigación Pesquera*). Founded in 1955 [MARRASÉ y ABELLÓ, 2005], it is far from being capable of capturing long-term contributions as against those in the IEO's publications, where the results of statistical bibliography were available since two decades earlier [DE BUEN, 1932]. Out of the 707 bibliographical references quoted in the 36 articles of authoresses as published in the IEO's journals, only 1.5 % were addressed to CSIC's publications. Communication in the converse direction is also limited in retrospect as regards the IEO's editors. Out of the 202 references quoted in the 18 published articles of CSIC's authoresses, 6 % are addressed to IEO's journals. For that reason, the possibilities in retrospect of designing a reconstruction of scientific developments are few in terms of interbreeding.

The average number of prior publications on which each article is based comes close to value 13, since an average 19.62 items are referenced from the science generated by IEO as against an average 11.22 for CSIC, the geometric mean of these last two averages being 14.8. This is a structure that Price [NALIMOV, 1981, p. 154] describes, rather picturesquely, as a 13-degree sexual system.

Table VI. IEO-CSIC Inter-communication

Organisation	Articles	References	Mean value	Reference to the other organisation	Percentage (%)
IEO	36	707	19.63	11	1.5
CSIC	18	202	11.22	12	6

Conclusions

The IEO's female researchers, who have few solo articles, were the most prolific and evinced a higher average productivity as compared both with the males in their own Institute and with their female colleagues at CSIC. The prevailing situation appears to be reflected on an international scale, for the influence of the published articles of the IEO's authoresses reach twofold the number of countries as against the influence of the CSIC's female specialists.

However, the degree of communication between the female authoresses of both Spanish organisations happens to be very low, whereas the CSIC's authoresses are much more recognised by their own organisation than are their colleagues at IEO. Their topical and creativity similarities are to be added to these patterns. A content that do not differ and predictions that address similar creativity criteria are thus generated from CSIC (IIP) and IEO. No doubt, all this is related to the particular identity of each organisation and to their degree of inter-communication, as well as to the international stream of propagated findings.

For another thing, although we have remarked that the accession of females authoresses to IEO was consolidated during the 1941-1951 decade with eight researchers, no new authoress joined this Institute within the 1951-1969 period. The opposite situation is observed in the case of CSIC, where seven new authoresses gradually joined this organisation. This development, which apparently coincided with a new socio-political situation¹⁵, culminated with the establishment, by the Advisory Committee on Scientific and Technical Research (Comisión Asesora de Investigación Científica y Técnica, CAICYT), of an specific fund amounting to 100 million pesetas¹⁶. This fact can be considered as the theoretical origin of the current management system represented by the National Plan for R&D. Under this Plan (years 2002-04), the number of proposals put forward by female PhDs in marine science represents 26% of the total¹⁷. The 53 female researchers on the current IEO's staff reaches a higher proportion (32%)¹⁸, which can be deemed inadequate if we take into account the increases reached in the past (13 % in 1928, 17 % in 1932 and 25 % in 1948-1949).

As to marine science in particular, it is surprising to verify that, despite the above-described independent historical development between IEO and IIP (failing a State policy intended to strike a balance), the current situation between IEO and CSIC (Marine Division) is very similar. Indeed, both organisations equally share the existing 20 territorial marine centres

¹⁵ Major developments began to take place in this country, such as discontinuance of Rationing Cards, accession as a member of UNESCO (1952), the number of CSIC's constituent establishments is increased to 141, the first full-term female university professor takes office (1953), females represent an average 15 % of the total university student body (1954), promulgation of a Womens' Rights Act (1961), etc.

¹⁶ PORTELA [1991, pp. 38-39].

¹⁷ Source: *Boletín CYTMAR*, 72 (February 2005).

¹⁸ Similar value in the present-day CSIC [CSIC, 2005].

and the 1,000 workers on their combined staffs with female/male researcher ratio in the same proportion (1:3).

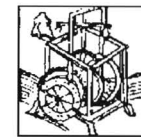
REFERENCES

- CSIC (2005) *Informe mujeres investigadoras 2005*. Secretaría General. Subdirección General de Recursos Humanos.
- DE BUEN, F. (1932) "Las publicaciones del Instituto Español de Oceanografía (1916-1932)". *Boletín de Oceanografía y Pesca*, año XVII (Nº 1), 2-4.
- GUERRA, A. y PREGO, R. (2003) *El Instituto de Investigaciones Pesqueras. Tres décadas de la investigación marina española*. Madrid, CSIC, 341 pp.
- HOADLEY, A.B. y KETTENRING, J.R. (1990) "Communications between statisticians and engineers/physical scientists". *Technometrics*, 32 (3), 243-247.
- ICES (1949) "Experts engaged on Fisheries Research in the Council's Area". En: *Rapports et Procès-Verbaux des Réunions*. Volume 124. 1^{ère} Partie Procès-Verbaux (Octobre 1948), 26-27.
- IEO (1953) *Informe sobre la pesca en España, redactado por el Instituto Nacional de Oceanografía, a petición de la Dirección General de Pesca Marítima*. Madrid, 46 pp.
- LÓPEZ PINERO, J.M. y TERRADA, M.L. (1993) *Veinte años de investigación bibliométrica en el Instituto de Estudios Documentales e Históricos sobre la Ciencia*. Valencia, Universidad-CSIC.
- MARRASÉ, C. y ABELLÓ, C. (2005) "Foreword." *Scientia Marina*, 69 (Supp.1), 3-4.
- NALIMOV, V.V. (1981) *Faces of sciences*. Philadelphia, ISI Press.
- NOWAKOWSKA, M. (1975) "Measurable aspects of the concept of scientific career". En: *Determinants and controls of scientific development*. Dordrecht-Holland, D. Reidel, 295-322.
- NOWAKOWSKA, M. (1977) "Monopolization and alienation in science: a formal approach". *Behavioral Science*, 22, 313-326.
- PORTELA, E. (1991) "Las Instituciones". En: *España. Ciencia*. Madrid, Espasa-Calpe, 29-71.
- PRICE, D. de S. (1986) "Citation measures of hard science, soft science, technology and non-science". En: *Little Science, big science ... and beyond*. N.Y., Columbia University, 155-179.
- ZUSNE, L. (1976) "Age and achievement in psychology. The harmonic mean as a model". *American psychologists*, 31, 805-807.

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TOMO II



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