



RESEARCH ARTICLE

Bibliographic Coupling Indicators for the evaluation of theoretical-methodological proximity in academic genealogy networks a study applied to the PQ fellowship researchers descending from Aldo Barreto

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ABSTRACT

This study analyzes the contribution of the Bibliographic Coupling Method to evaluate the transmission strength of the theoretical-methodological current of a researcher among his academic descendants. The universe of analysis was the set of PQ fellowship doctors supervised by Aldo Barreto, Senior PQ researcher in the area of Information Science. The methodological procedure retrieved the set of articles published by Aldo Barreto and his PQ scholarship descendants. Next, we identified the authors cited in this research corpus and calculated the normalized rates of Author Bibliographic Coupling between Aldo Barreto and the analyzed descendant researchers. The strongest theoretical proximity occurred between Aldo Barreto and his students Maria N. González de Gomez, Regina M. Marteleto and Carlos H. M. Almeida. We observed a steady influence by Pierre Bourdieu and Michel Foucault in the academic genealogy network. We concluded that the Bibliographic Coupling Method contributed to the analysis of the transmission strength of scientific identity in the genealogical lineage of the group of studied researchers.

KEYWORDS

Aldo Barreto. Bibliographic coupling. Citation analysis. Research grants. Information Science.

Indicadores de Acoplamento Bibliográfico para a avaliação da proximidade teórico-metodológica em redes de genealogia acadêmica um estudo aplicado aos descendentes bolsistas PQ de Aldo Barreto

RESUMO

Este estudo analisa a contribuição do Método de Acoplamento Bibliográfico para a avaliação da intensidade da transmissão da corrente teórico-metodológica de um pesquisador entre seus descendentes acadêmicos. Como universo de análise, utiliza o conjunto de doutores bolsistas PQ orientados por Aldo Barreto, pesquisador PQ Sênior da área de Ciência da Informação. Como procedimento metodológico, recuperou-se o conjunto de artigos publicados por Aldo Barreto e seus descendentes bolsistas PQ. A seguir, identificaram-se os autores citados nesse corpus de pesquisa e calcularam-se os índices normalizados de Acoplamento Bibliográfico de Autores entre Aldo Barreto e os pesquisadores descendentes analisados. As proximidades teóricas mais intensas ocorreram entre Aldo Barreto e suas orientandas Maria N. González de Gomez e Regina M. Marteleto e seu orientando Carlos H. M. Almeida. Observou-se a constância da influência de Pierre Bourdieu e Michel Foucault na rede de genealogia

acadêmica analisada. Conclui-se que o Acoplamento Bibliográfico de Autores contribuiu para a análise da intensidade da transmissão da identidade científica na linhagem genealógica do grupo de pesquisadores estudados.

PALAVRAS-CHAVE

Aldo Barreto. Acoplamento bibliográfico. Análise de citação. Bolsas de pesquisa. Ciência da Informação.



JITA: BG. Information dissemination and diffusion.

1 INTRODUCTION

The scientific contribution generated by a researcher in a domain or area of knowledge can be recognized through different aspects of their performance; among them, their bibliographic and/or technological and innovative productions, such as scientific articles and patents, and the training of new researchers.

From the perspective of human resource training, the training of new researchers is built mainly through the relationship of academic mentoring between the advisor and the advisee. This relationship gains relevance for both parties, as students are in the process of scientific maturing and development and advisors, in the first supervisions, are in a process of consolidation in the domain they are inserted. In this context, the fact that academic supervision is part of the process of disseminating the advisors' knowledge and ideas is highlighted, especially in graduate programs (PPG), or even mandatory for rewarding, such as for example, a requirement for being granted a research productivity grant (PQ) from the National Council for Scientific and Technological Development (CNPq).

However, it is noteworthy that the advisor-advisee relationship does not occur only during academic or professional graduate (master's and doctoral) programs. This relationship can also be present during the student's training at the undergraduate level through scientific initiation supervision, which result in scientific documents submitted to journals and/or scientific conferences, in addition to the supervision of final papers. Specifically, regarding PPG, supervisors conduct and assist their supervisors during the preparation of their thesis (master's level) and their dissertations (doctoral level), so that these studies contribute to knowledge enrichment for both advisor and advisee, in addition to the progress of the field they are inserted.

For Ferreira, Furtado and Silveira (2009), the advisor-advisee relationship is arguably the basis of graduate studies. In this sense, a PPG student is a potential researcher, in an advanced stage of development on their way to scientific autonomy, but still dependent on an advisor professor, which justifies the importance and need for the supervised activities.

In Brazil, academic supervision at the graduate level is particularly significant, due to its positive impact on scientific production, as, in addition to new researchers' training and qualification, PPGs demonstrate their excellence, through the insertion of the knowledge generated in the scientific literature of the field they operate (MOREIRA; DIAS; MOITA, 2016). Thus, the scientific progress of the various scientific domains is directly related to the training and insertion of new researchers in these domains, in such a way that the constant renewal of researchers' training is essential for the development of new research.

In this context, it is possible to observe that science evolves through interactions, professional and social, among scholars, consolidated, especially, by the relationship between advisor and student, from which the transmission of theoretical-methodological currents and knowledge construction, a fundamental function for the socioeconomic development of a community (DAMACENO; ROSSI; MENA-CHALCO, 2017). This supervision relationship can be represented by trees (networks; graphs) of academic genealogy (AG), which contribute to the diachronic analysis of scientific group formations in different areas of knowledge (ROSSI; MENA-CHALCO, 2014).

Genealogy studies can be understood as an auxiliary science of history, which seeks to investigate the origin, evolution and dissemination of groups interconnected by family ties or another type of connection that reveals commonalities among the parties. Thus, these studies aim to identify the ancestors and descendants of an individual (ROSSI; DAMACENO; MENA-CHALCO, 2019).

Also according to Rossi, Damaceno and Mena-Chalco (2019), academic supervision or mentoring activities are types of relationships that promote the evolution and dissemination of: groups of researchers, the institution they are inserted, science as a whole, and society. Thus, promoting studies involving academic supervision structured in a genealogical way, represented by networks (trees) of academic genealogy, generates means to analyze the impact of certain actors (researchers) in the network they are inserted, allowing visualization of the domain they belong to according to the genealogical representation.

Thus, academic genealogy studies aim to observe the contribution of researchers, individually or collectively, in the training and qualification of new researchers in a given academic supervision network. Furthermore, they promote diachronic visualization on how theoretical and methodological currents spread over time, in order to examine knowledge transmission and succession between supervisors and students. Thus, the analysis of academic genealogy can contribute to the study of the intellectual heritage of the various scientific domains, operationalized by the interdependent relationships between new researchers (advisees) and more experienced researchers (advisors).

In this same sense, Sugimoto (2014) defines studies of academic genealogy as the quantitative analysis of intellectual heritage arising from the relationship between advisor and advisee. This type of study can generate means to understand the contribution of supervision in maintaining intellectual legacy. Thus, academic genealogy allows to analyze, within the scope of formalized and institutionalized academic mentoring, not only individual aspects, but also collective aspects of the scientific formation of a certain area of knowledge.

In this context, many studies have focused on the construction and analysis of the tree of one single researcher, as in the studies of Tyler and Tyler (1992), Stella (2001), Bennett and Lowe (2005), Rossi and Mena-Chalco (2014), Gabriel Junior and Bufrem (2018). In addition, several areas of knowledge, especially Mathematics (MALMGREN et al., 2010; CHANG, 2011; ROSSI; MENA-CHALCO, 2014), Neurosciences (DAVID, HAYDEN, 2012), Chemistry (ANDRAOS, 2005) and Public Health (VIANA et al., 2019) have been conducting academic genealogy studies for groups of researchers and their academic mentoring relationships.

The importance of genealogical analyzes in the academic field, especially those arising from the PPGs, reveals ways of assessing the impact of academic supervisions on scientific development and on the identification of the main actors (researchers and/or scientific communities) who have stood out for their contributions to knowledge dissemination (intellectual inheritances) through this type of relationship (ROSSI; MENA-CHALCO, 2014).

The association between researchers becomes more evident through the citations made in their works, promoting the recognition of the citing party in relation to the cited work. In this scenario, the authors (citing) constantly mention their influencers (cited), continuing their theories in different contexts and maintaining the knowledge produced by their predecessors throughout history (BUFREM; SILVA; SOBRAL, 2017).

Thus, supervision relationships, represented by academic genealogy networks, have become a fertile field for the application of metric studies of information, especially of relational citation analyzes. Through citations perpetuated by both parties (advisor and advisee), the main influencers in a scientific domain are identified, in this case, specifically represented by generations of academic supervisions.

As presented by Oliveira et al. (2018) in reference to Rossi et al. (2018), there are several metrics described as genealogical, that is, those that can be understood as quantitative properties that include topological aspects of an academic genealogy network, such as fertility (number of students; academic children), descendancy (total quantity of a researcher

descendants, all generations are considered: children, grandchildren, great-grandchildren, etc.) and generations (number of academic lineages in a network).

However, such metrics contemplate the temporal evolution and network diffusion through new members that are inserted in it, different from the citation metrics, such as citation analysis, co-citation and bibliographic coupling, which highlight the relationship between citing-cited, cited-cited and citing-citing, respectively. In addition, from the perspective of representation by social networks, these relationships are evident through the links (connections) present in the network and not necessarily by the actors' individual properties. Consequently, the valuation of these connections, represented by the link thickness, identifies the variability of the strength of the links between the authors according to the proposed analysis (citation, co-citation or bibliographic coupling).

Specifically in relation to bibliographic coupling, derived from the studies by Kessler (1963), the overlap between the reference lists of two articles corresponds to the strength or frequency of bibliographic coupling between them, that is, their coupling is defined by the number of common cited documents.

Continuing the studies by Kessler (1963, 1965), Zhao and Strotmann (2008, 2014) present author bibliographic coupling (ABC) that seeks to establish the proximity between two authors, and no longer between two articles, from the analysis of the overlap between their bibliographic reference lists. In this context, Grácio (2016) clarifies that both the choice of researchers (authors) and the way in which ABC is calculated can directly interfere in the search result.

In line with the aforementioned authors, it is possible to point out that ABC calculation can take place from two perspectives: i) Documentary: the calculation of coupling strength between authors is based on the number of common cited documents by both; ii) Between authors: the calculation of coupling strength between two analyzed researchers is based on the number of common cited authors. In this perspective, the author's publications that were cited are not differentiated, but only their recitation (citation recurrence) in the work of the analyzed researcher.

In this second case, when a researcher cites different documents from the same author, the researcher's recitation strength in relation to the cited author is equal to the total number of cited documents. Thus, in this perspective, the overlap between the reference lists of two researchers is formed by the different common cited authors, weighted by the frequency of recitation to each of them. It is noteworthy that both ways of calculating ABC reveal the citing-citing relationship between authors and not between articles, even if the ABC strength is calculated according to the first perspective (number of common articles, weighted by the intensity of recitation of each article).

Grácio (2020) adopts the method of counting the cited author's work as unique (perspective ii) to analyze the author's recitation. Through recitation, ABC complies with the concept of scientific identity, proposed by White (2001). Citing an author in several publications (two or more) throughout a researcher's scientific trajectory reveals the author's influence on the researcher's work and composes the researcher's citation identity. When this cited author also forms the citation identity of another researcher, it forms a link (coupling) between the two researchers and thus participates in the set of cited authors formed by the overlapping citation identities of the two researchers.

In this context, associating AG studies with ABC indicators, as a methodological proposal for the analysis of AG networks from a researcher or an exponent group in a scientific domain, may offer a new genealogical metric, based on the existing connections of the supervisor-student relationship, represented by the links of the network valued by ABC indexes

between advisor-advisee, which describe the strength with which scientific currents are preserved by generations of academic supervision.

Given the above, the research problem is: how does the author bibliographic coupling behave as a methodological proposal for measuring the strength of the links in a researcher's academic genealogy network in the field of Information Science?

To answer to presented question, this research analyzes the contribution of the association of the author bibliographic coupling method to the study of Aldo Barreto's academic genealogy network, an exponent researcher in the field of Information Science, for visualizing the transmission strength of his theoretical-methodological current among his PhD students who received CNPq's PQ fellowship.

The only senior productivity fellow from CNPq in the area of Information Science, doctoral and master's degree in Information Science at The City University of England, Aldo de Albuquerque Barreto (1941-2018) graduated in Economic Science from the Federal University of Rio de Janeiro. Among his numerous contributions to the area of Information Science, we highlight the inauguration of the PPG in Information Science of the Brazilian Institute of Information in Science and Technology (IBICT) in Rio de Janeiro, publisher of the electronic journal DataGramaZero for four years, the lifelong title of Senior Researcher from the Ministry of Science and Technology/IBICT granted as recognition of a life dedicated to research in science and technology (GABRIEL JUNIOR; BUFREM, 2018).

By seeking to offer indicators that contribute to a more comprehensive analysis of the intellectual heritage preservation in academic supervision relations, configured by the theoretical and methodological current in which the advisor works, this research aims to contribute both to the field of academic genealogy studies, by providing an objective method of tracking the maintenance of scientific currents in a field of knowledge and to the development of bibliometric studies, by exploring the potential application of one of its methods. The combination of the author bibliographic coupling study, applied to an expressive scientific universe, characterizes the integration between the groups G1 (bibliometric studies of "base") and G2 (bibliometry applied to scientific information), proposed by Glänzel (2003), as the object of study (ABC) is analyzed empirically, that is, applied to a group of PQ researchers in the field of Information Science.

2 METHODOLOGY

Considering that the objective of genealogical research is linked to the investigation of an individual's ancestors and descendants, and that the identification of links between individuals can be found in historical records, that is, in documents that provide evidence of their connections (ROSSI; MENA-CHALCO, 2014) and through the curricula registered in the Lattes platform, this research presents an analysis of Aldo Barreto's academic descent in relation to his doctorate students who became PQ fellows.

The analysis of the academic genealogy network composed by Aldo Barreto's supervisions and his descendants with PQ fellowships stems from the scientific expressiveness of researchers who achieve this type of grant, in addition to the fact that Aldo is the only researcher in the area of Information Science to be contemplated with Senior level of this type of grant. The PQ fellowship is offered by CNPq public calls and is granted to researchers, necessarily doctors, with a notable prominence in terms of scientific, technological and innovation production, in addition to the training of human resources in their respective scientific fields.

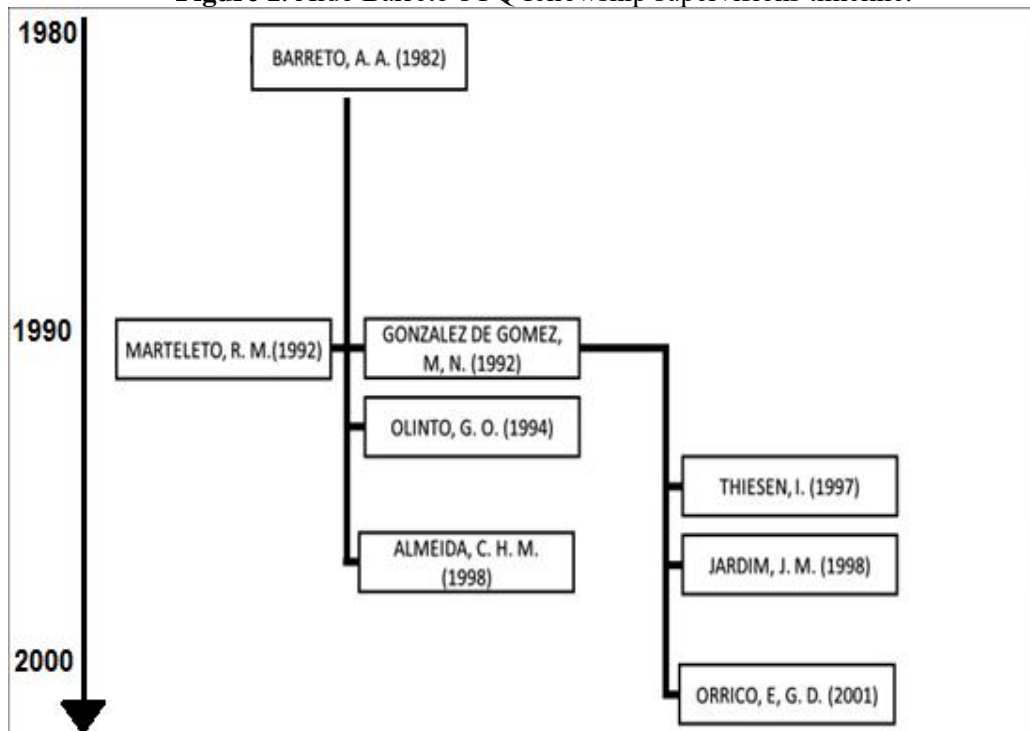
PQ fellows represent a group of researchers funded by CNPq to develop scientific projects with a significant contribution not only to the advance of the area of knowledge they are linked to, but also to national science as a whole. In addition, this group, considered to be of scientific excellence, is characterized mainly by high productivity.

From Lattes Platform consultation, it was observed that Aldo Barreto supervised nine master's thesis and 16 doctoral dissertations. Among the 16 doctoral graduates, after consulting the CNPq website in August 2018, it was observed that 4 were active PQ fellows in 2018. In Figure 1, the timeline of Aldo Barreto's supervisions is presented specifically regarding their PQ fellowship descendants, who followed his research productivity steps.

There are two generations of PQ researchers' supervisions (Figure 1): i) Academic children: composed of four fellows; ii) Academic grandchildren: composed of three graduates supervised by PQ fellows González de Gomez (the only Aldo Barreto's descendant with students, doctors and also PQ fellows).

Thus, in terms of genealogical metrics, which explain topological characteristics of an academic supervision network, when considering only PQ fellowship researchers, the fertility of Aldo Barreto's academic supervision network is equal to 4 researchers, the descendance equal to 7 researchers, and two generations of PQ fellows. It is also noteworthy that González de Gomez's fecundity is equal to 3, with descendants of PQ fellowship holders equal to 3 and one generation.

Figure 1. Aldo Barreto's PQ fellowship supervisions timeline.



Caption: date in parentheses refers to the researcher's doctoral year. Source: by the authors

To calculate the ABC index between supervisor (Aldo Barreto) and his PhD PQ graduates (R. Marteleteo; MN Gonzalez de Gomez; Gilda Olinto; CHM Almeida), and between Gonzalez de Gomez and her three doctoral students with PQ fellowships, in August 2018, Aldo Barreto's and his seven descendants' curricula in Figure 1 were retrieved from the Lattes platform. For each researcher, all produced articles were identified.

For each of the eight analyzed researchers, the set of articles considered in the ABC analysis was formed only by those in which he occupied the position of first author. In addition to this criterion, for the supervisors researchers (Aldo Barreto; M.N.Gonzalez de Gomez), articles were excluded when the student for whom the ABC index was being calculated was listed as co-author. On the other hand, for the supervising researchers, the same additional criterion was applied, that is, their articles were excluded when the advisor was listed as a co-author.

Of the total of 289 articles published together by the eight researchers in Figure 1, 230 met the aforementioned criteria. Table 1 shows the distribution of article production among the researchers under analysis.

It is noteworthy that Aldo Barreto did not write any article in co-authorship with his students and, in only one of his articles, there is an authoring relationship with another researcher (without no academic supervision). Thus, in all ABC index calculations in which he was involved as a researcher, his considered set of articles was the same; that is, 39 articles. Such fact may imply in supervisions in which the advisor encouraged the independence of their students. In addition, it is noted that his career was characterized by the fact that he is an extremely independent researcher in terms of authorship.

Table 1. Researchers’ total articles and research corpus (230 articles).

Advisor	Descending Researcher	Researcher’s Total Articles	Researcher’s Total Articles after Applying the Criteria	Research Corpus
Aldo A. Barreto (39 articles)	Maria N. G. Gomez	40	34	32
	Regina M. Marteleto	58	45	42
	Gilda O. Olinto	20	16	16
	Carlos H. M. Almeida	41	33	33
	José M. Jardim	38	36	32
	Icléia Thiesen	27	23	20
	Evelyn G. D. Orrico	26	16	16
Maria N. G. Gomez (32 articles)	José M. Jardim	38	34	32
	Icléia Thiesen	27	23	20
	Evelyn G. D. Orrico	26	15	15
			Total	230

Source: By the authors.

The analysis of ABC paired between advisors and students of Aldo Barreto’s academic genealogy network (Figure 1) was performed to measure the strength of intellectual inheritance in the advisor-advisee relationship. For this, initially, for each researcher (Aldo Barreto and his descendants), the set of authors present in their reference lists was identified. It is highlighted that the work of the cited authors was considered as unique, that is, the title of the cited works was not discriminated, but only the names of the authors present in the reference list of each article which respected the pre-established criteria.

Then, for each researcher, the recited authors (cited two or more times), that is, authors who appeared in two or more of the researcher’s articles were identified. It is clarified that institutional authorship was not considered in the analysis. Table 2 shows the corpus of cited

and recited authors by each of the eight analyzed researchers. The data related to the recited and reciting authors supported the ABC analysis among the eight researchers that make up the analyzed academic genealogy network.

Table 2. Cited and recited authors and recitations of the analyzed researchers.

Researchers in the analyzed academic genealogy network	Total analyzed articles	Cited Authors	Recitados Authors*	% of recited authors	Total recitations	Mean recitation per recited author
Aldo A. Barreto	39	195	71	36%	406	6
Regina M. Marteleto	42	267	73	27%	304	4
Maria N. G. Gomez	32	432	132	31%	545	4
Gilda O. Olinto	16	212	50	24%	157	3
Carlos H. M. Almeida	33	692	234	34%	842	4
Icléia Thiesen	20	187	51	27%	188	4
José M. Jardim	32	250	29	12%	90	3
Evelyn G. D. Orrico	16	87	20	23%	65	3

*cited at least twice. Source: By the authors.

From the data shown in Table 2, it is assumed that the research corpus (recited authors) constitutes a significant portrait of the cited identities of the analyzed researchers, as, except for José M. Jardim, the recited authors configured between 23% and 36% of the authors cited in their respective works. These percentages show that the analyzed researchers have adopted a cohesive and recurrent theoretical and methodological nucleus throughout their scientific trajectories. This regularity is reflected in the mean recitation per recited author, which varied between 3 and 6 recitations per recited author, that is, the recited authors appeared, on average, in 3 articles of the articles by G. Olinto, J.M. Jardim and E.G.D. Orrico and, on average, in 6 articles by A. Barreto. Furthermore, as Information Science is an interdisciplinary scientific field, with theoretical and methodological influence coming from several areas, such as Semiotics, Sociology, Linguistics, Logic, Mathematics and Psychology, among others (GONZALEZ DE GOMEZ, 2003; PINHEIRO, 2005, 2006), the percentages obtained for the recited authors and their recitation averages in the researchers' works make the representativeness of the research corpus (set of recited authors) even more significant as the scientific identity of the analyzed researchers. Consequently, it is assumed that the results of the ABC analysis applied to the analyzed researchers are significant in relation to their theoretical-methodological proximity.

Next, the normalized ABC indexes were calculated pair to pair for the researchers in Figure 1, among which there is an academic genealogy relation, in a total of 10 ABC indexes, corresponding to 10 academic genealogy relations, on the following path: i) obtained the ABC value according to the number of common recited authors by the advisor and the student; ii) the ABC value, presented by Zhao and Stroman (2008) and Grácio (2020), resulting from the sum of the minimum citation values for each common cited author in relation to the number of citation by the supervisor and the student; iii) The values obtained in the previous item (ii) normalized by the Salton Cosine. As an explanation for the procedure (ii), it is exemplified: if an author X was cited in 5 articles by the advisor and 2 articles by the student, and another

author Y was cited in 3 articles by the advisor and in 7 articles by the student, author X adds 2 and author Y adds 3 to the total ABC value.

The Salton Cosine as a similarity index for ABC normalization between two researchers A and B is defined by:

$$CS_{ABA}(A, B) = \frac{ABA(A, B)}{\sqrt{Recit(A) \times Recit(B)}}$$

In which:

- $CS_{ABA}(A, B)$: bibliographic coupling index between authors A and B normalized according to the Salton Cosine;
- $ABA(A, B)$ value of the bibliographic coupling between authors A and B according to the recitation of the most cited authors (value obtained in procedure ii previously described);
- $Recit(A)$ and $Recit(B)$ Total of the authors' recitations cited by researcher A and B, respectively.

The normalization of the absolute ABC values results in indexes that vary between 0 and 1, in which the closer to 1 the higher the theoretical and methodological proximity between the authors, measured by the overlap of the recited authors. The closer to zero, the lower the authors' similarity regarding the theoretical framework adopted in their works. The 10 calculated ABC indices were: between Aldo Barreto and his four students, between Maria N. González de Gomez and her three students, and between Aldo and Maria N. González de Gomez's three students. It should be noted that self-citations were considered at ABC.

3 RESULTS

Chart 1 presents the 18 recited authors (and the number of documents they are present), responsible for the bibliographic coupling between the researchers who form Aldo Barreto's academic genealogy network presented in Figure 1, that is, those cited in common by at least one of the advisor-advisee dyads in Figure 1. The list of recited authors allows the identification of the main common theoretical-methodological influences (authors) in the academic supervision relations in Figure 1. The theoretical-methodological current adopted by Aldo Barreto is considered to represent one of the perspectives of his intellectual heritage to his descendants.

From Chart 1, it is highlighted that Pierre Bourdieu influences the majority (6 out of the 8) of the researchers that make up the academic genealogy network represented in Figure 1: Aldo Barreto and five of his descendants. It is also possible to observe Michel Foucault in the work of most of the analyzed researchers (5 out of the 8 reference lists), cited by Aldo Barreto and four of his descendants (two direct descendants and two descendants of the second generation). This result shows that these authors significantly make up the scientific identity of this genealogical network.

Chart 1. Recited authors who coupled the analyzed researchers

Author Recitation per documents	Analyzed Researchers								Total Recitations
	A. Barreto	R. M. Marteleto	G. O. Olindo	C. H. Almeida	M. N. González Gomez	J. M. Jardim	I. Thiesen	E. G. D. Orrico	

Barreto, A. A.	11						2		13
Belkin, N.	3	2		3	6				14
Bourdieu, P.	9	15	4		6	2	3		39
Buckland, M.	4			4					8
Eco, U.	3			2	1				6
Foucault, M.	6	5			10		13	3	37
González de Gomez, M. N.					20	4	2	1	27
Jardim, J. M.					3	13			16
Habermas, J.	10	3			16				29
Lancaster, F. W.	6			5					11
Lévy, P.	7	3		5	2				17
Morin, E.	4			3	3				10
Price, D. S.	1							2	3
Robertson, S. E.	1				2				3
Saracevic, T.					2		1		3
Simon, H.	2				2				4
Wersig, G.	4	3			7				14
Wittgaisten, L.	4				10				14
Total Recitations	75	31	4	22	90	19	21	6	-

Source: By the authors.

In addition, given that self-citations are not excluded, Aldo Barreto, M. N. González de Gomez and J. M. Jardim are cited and citing authors, that is, they are present both in the lists of citing authors and in the lists of cited authors. Furthermore, researcher M. N. González de Gomez, the most fertile student in terms of new PQ fellowship supervisions, is present in the list of recited authors of his three student descendants: J. M. Jardim, I. Thiesen and E.G.D. Orrico.

Once the list of coupling authors (Chart 1) of the eight researchers analyzed by the academic genealogy link is presented, Table 3 presents the three ABC matrices among these researchers: with absolute values referring to the number of common recited authors (procedure i of the methodological path); sum of the weighting of each common recited author by the minimum frequency of recitation by the two researchers participating in the calculation (procedure ii); normalized ABC value (value obtained in procedure ii, normalized by the Salton Cosine).

Table 3. Matrices of Author Bibliographic Coupling (ABC) between advisor and descendant, resulting from each of the 3 procedures.

Researchers	M. N. G. Gomez	R. M. Marteleto	C. H. M. Almeida	G. O. Olinto	E. G. D. Orrico	I. Thiesen	J. M. Jardim
Matrix 3a	ABC in absolute values (Methodological Procedure i: number of cited authors in common)						
Aldo A. Barreto	11	6	6	1	2	3	1
Maria N. G. Gomez	-	-	-	-	2	5	3
Matriz 3b	ABC weighted by recitation intensity (Procedure ii: sum of the authors' minimum recitation values in different articles)						
Aldo A. Barreto	42	24	22	4	4	11	2
Maria N. G. Gomez	-	-	-	-	4	18	9
Matriz 3c	Normalized ABC (Procedure iii: matrix 3b relativized by Salton's Cosine)						
Aldo A. Barreto	0,09	0,07	0,04	0,02	0,03	0,04	0,01
Maria N. G. Gomez	-	-	-	-	0,02	0,06	0,04

Source: By the authors.

From Table 3, it is highlighted that Aldo Barreto and Maria N. González de Gomez have the highest theoretical and methodological proximity, when analyzed from the number of common cited authors (11 authors cited at least twice) in Matrix 3a. Almost twice the second biggest number of common cited authors observed between Aldo Barreto and his descendants (with R. Marteleto and with C.H.M. Almeida). It is noteworthy, however, that these 11 authors represent only 15% of the set of 71 authors recited by Aldo Barreto and 8% of the 132 authors recited by Maria N. González de Gomez.

Moreover, the bibliographic coupling strength between Aldo Barreto and his students Regina M. Marteleto and Carlos H. M. Almeida, represented by 6 common cited authors between them and Aldo Barreto, correspond to 8% and 3%, respectively, of the total number of authors recited by these descendant researchers and 8% of the authors recited by A. Barreto. Thus, although M. N. González de Gomez and Regina Marteleto have different number of common recited authors with Aldo Barreto (their advisor), proportionally in relation to the size of the set of authors that supports his research (authors recited in their articles), the strength of proximity to A. Barreto proves equivalent. On the other hand, in relation to Carlos H. M. Almeida, the overlap regarding his universe of recited authors is quite small (3%).

Regarding the researcher Maria N. González de Gomez and her three students (Aldo Barreto's second generation), the ABC strength between her and her descendant researchers equals to 2, 5 and 3 common recited authors between the advisor and her students. In other words, 4% in relation to the total number of authors recited by Evelyn G. D. Orrico, 9.8% in relation to the list of authors recited by Icléia Thiesen and 10.3% in relation to the authors

recited by José M. Jardim. These values correspond to 1.51%, 3.79% and 2.27% of the total number of authors recited by the advisor.

In addition, it is highlighted that Aldo Barreto is bibliographically coupled with all his descendant researchers, whether from the first or second generation of academic supervision, with at least one common recited author, that is, his descendants recurrently adopt at least one of the authors who support Aldo Barreto's theoretical-methodological framework. In this way, Aldo Barreto's academic genealogy network originating from the PQ fellowship supervisions constitutes a highly productive scientific domain, in which his descendants, more or less intensely, are connected with Aldo Barreto.

The absolute indices in Matrix 3b (sum of the minimum recitation values between the two researchers) reinforce the previous observation regarding the theoretical and methodological proximity between Aldo Barreto and three of his first-generation students (Maria N. González de Gomez, Regina M. Marteleto and Carlos H. M. Almeida), maintaining the same strength trends, given the number of recitations to the authors present in their respective reference lists from the analyzed articles.

From this perspective, regarding Aldo Barreto's students, the most influential coupling authors in his works are N. Belkin (present in the works by Maria N. González de Gomez, Regina M. Marteleto and Carlos H. M. Almeida), P. Bourdieu (present in the works by Maria N. González de Gomez, Regina M. Marteleto and Gilda O. Olinto), P. Lévy (present in the works by Maria N. González de Gomez, Regina M. Marteleto and Carlos H. M. Almeida). Regarding Aldo Barreto's second generation of supervisions, both P. Bourdieu's (present in the works by Icléia Thiesen and José M. Jardim) and M. Foucault's influences (present in the works by Evelyn G. D. Orrico and Icléia Thiesen) are noted. It is highlighted that, when calculating the frequency of recitations to authors in the various published articles, it is possible to identify their constancy in the works of the analyzed researchers and, thus, to characterize the main theoretical and methodological references maintained by the researchers in their scientific trajectories, as also pointed out by Bufrem, Silva and Sobral (2017).

When analyzing the proximity between Maria N. González de Gomez and her students, the authors M. Foucault (present in the works by Evelyn G. D. Orrico and Icléia Thiesen) and P. Bourdieu stand out (present in the works by Icléia Thiesen and José M. Jardim). The presence of Maria N. González de Gomez in the list of authors recited by her PQ fellowship descendants suggests a higher influence of her work in her students' articles, when compared with Aldo Barreto and her students, since Barreto does not constitute a coupling author with none of his direct descendants; only with Icléia Thiesen (second generation; academic granddaughter).

On the other hand, it is noteworthy that, although Maria N. González de Gomez is an author who couples with all her students, that is, the supervisor is recited by her and by all three of her descendants, the recitation frequency of her works in her descendants' articles is low: 1 article (out of 15 retrieved, equivalent to 7%) by Evelyn G. D. Orrico, and 2 articles (out of 20 retrieved, equivalent to 10%) by Icléia Thiesen. Specifically regarding her student José M. Jardim, the cross-coupling between the researcher and his supervisor stands out, that is, José M. Jardim is present in the list of recited authors by supervisor Maria N. González de Gomez, and the supervisor is also present in the list of authors recited by the student. Maria N. González de Gomez is present in 4 of the 32 articles retrieved from José M. Jardim, and Maria N. González de Gomez recited José M. Jardim in 3 of her articles.

In contrast, even though Aldo Barreto is the generating and most ascending vertex of the analyzed genealogical network, his lesser influence was noted, in terms of reciting his work (advisor) in his descendants' work (students and his students' students). This observation stems from the fact that his students did not recite him, that is, they did not cite him in more than one

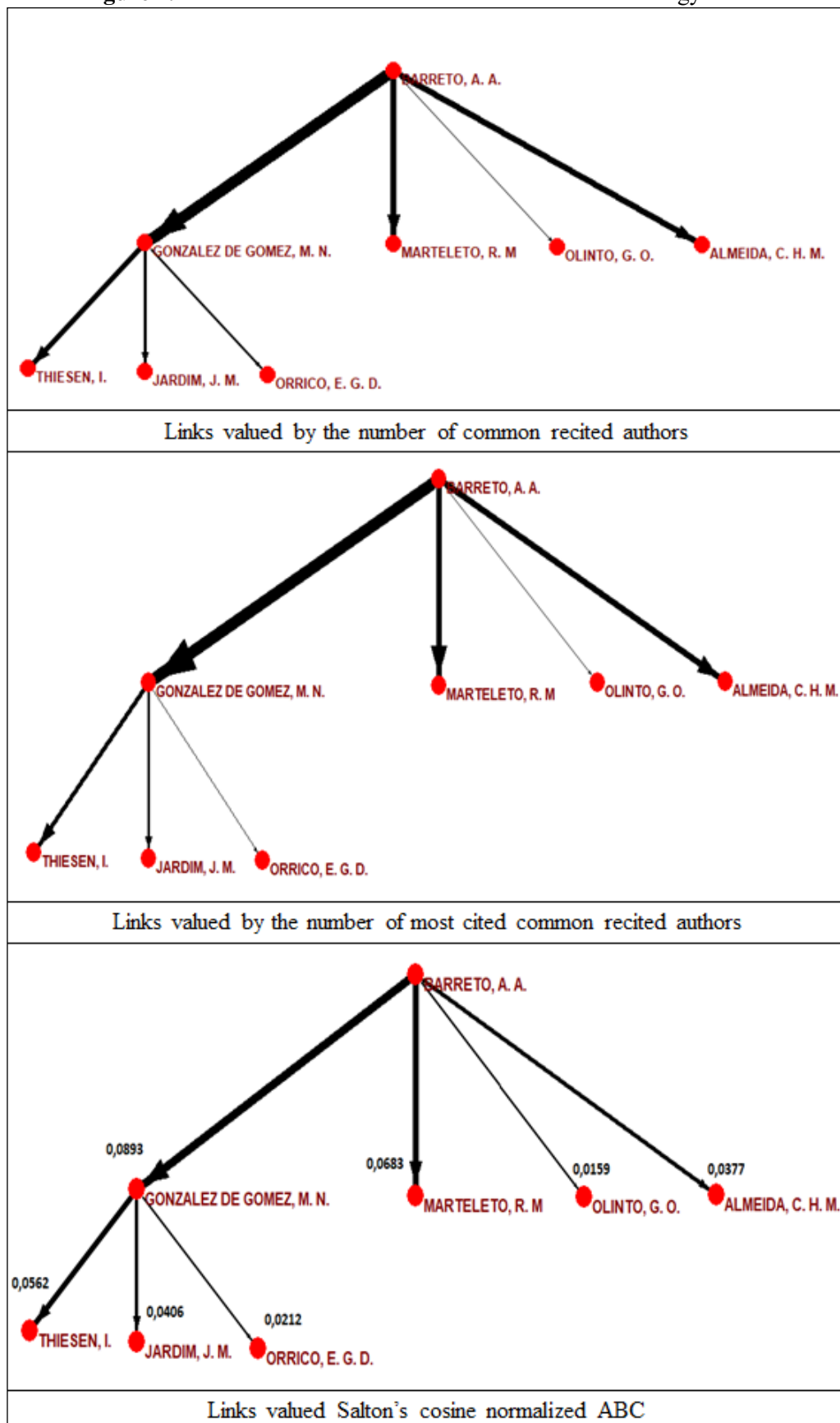
article, except from Icléia Thisen's work, in which A. Barreto is present in 2 of the 20 retrieved articles.

In this sense, the greatest influence of this network is related to the author Pierre Bourdieu. The author was mentioned in 6 of the 8 reference lists of the analyzed researchers. In addition to Bourdieu, Michel Foucault is also a very influential author in the analyzed academic genealogy network, present in the lists of theoretical references of 5 out of the 8 researchers in the network. Both authors are present at the same time in 4 out of the 8 reference lists of the PQ fellows appearing as recurrent theoretical references in the articles of the following researchers: Aldo Barreto, Regina M. Marteleto, Maria N. Gonzalez de Gomez and Icléia Thiesen. Thus, when cited together (co-cited), Bourdieu and Foucault have assiduously woven, in a combined way, the theoretical foundation of these four researchers' work.

Due to the differences between the number of articles published by the analyzed researchers (Aldo Barreto and descendants), which directly influences the number of authors recited in their works, ABC indexes were normalized through the Salton Cosine (Matrix 3c of Table 3). It is recalled that the normalized ABC indexes were relativized according to the total number of recitations to authors recited by each researcher involved in the ABC index. It can be observed (Matrix 3c, Table 3) that there was no difference in the ordering of the theoretical-methodological proximity between the researchers, that is, the highest theoretical-methodological similarity still consists of that between Aldo Barreto and M. N. G. de Gomez and the lowest proximity between A. Barreto and J.M. Jardim. However, the strength of proximity between the researchers changed, with some becoming more prominent in relation to the absolute results of ABC indicators (matrix 3a and 3b), such as those between Aldo Barreto and E. G. D. Orrico, and between A. Barreto and I. Thiesen and others acquired less prominence such as that between A. Barreto and C. H. Almeida.

In order to facilitate the visualization of changes in strengths of theoretical and methodological proximity between Aldo Barreto and his descendants from the three perspectives of the ABC indicator, Figure 2 was constructed. In this figure, the links in the academic genealogy network are illustrated according to the values obtained for the three ABC indicators (total of common recited authors - matrix 3a; total of recited authors weighted by recitation strength - matrix 3b; index normalized by the Salton Cosine - matrix 3c), in which the links (connections) are proportional to the index values from each perspective.

Figure 2. A. Barreto and his descendants' Academic Genealogy Networks



Source: By the authors

When comparing the intensity of the links present in the trees shown in Figure 2, it is not possible to identify significant topological differences, as, in general, the thicker (stronger) connections between researchers remained in the three perspectives of ABC indexes, that is, in general, the identified theoretical-methodological proximity was maintained, regardless of whether the index was absolute or normalized. Small changes for greater evidence (represented by more thickening) of theoretical-methodological proximity from the normalized perspective of the index were observed for the dyads: A. Barreto - G. Olinto; A. Barreto - J. M. Jardim; M.N.G. de Gomez- E.G.D. Orrico. On the other hand, by relativizing the influences of the recited authors according to the universe of their respective recitations, the theoretical and methodological proximity between A. Barreto and C. H. Almeida acquires less significance. In this way, the theoretical-methodological proximity between Aldo Barreto and Maria N. González de Gomez; Aldo Barreto and Regina M. Marteleto; Maria N. González de Gomez and Icléia Thiesen stand out visually in the three versions of the ABC indicator. It is noteworthy that, although the ABC strength between Aldo Barreto and M. N. Gonzalez de Gomez's descendants is not represented by links directly interconnected between the researchers of the network, the theoretical-methodological link between Aldo Barreto and Icléia Thiesen was expressive by ABC.

It should also be noted that, although Carlos H. M. Almeida (A. Barreto's direct descendant) showed higher strength, in absolute terms, of theoretical methodological link with his advisor than Icléia Thiesen (Barreto's indirect descendant), the normalized indexes from ABC coupled Aldo Barreto with higher strength with his academic granddaughter (I. Thiesen) than with his mentee (C. H. M. Almeida). In addition, Icléia Thiesen and Aldo Barreto are coupled by Aldo Barreto's citations, confirming Barreto's influence on his academic granddaughter's work.

Thus, the association of ABC indexes with the academic genealogy network, as a measure of link strength (connections), contributed to the visualization of the maintenance of the theoretical-methodological current, transmitted by the relationship of academic supervision of an exponent researcher in the field of Information Science, which forms part of the intellectual heritage inherited by his students' students, enriching and refining the study of its academic genealogy chain.

Furthermore, the results presented in this study corroborate those by Gabriel Junior and Bufrem (2018), in which the most cited researchers in the works by Aldo Barreto and his doctoral students are identified (not necessarily future PQ fellows), based on indexed works in the BRAPCI database. Gabriel Junior and Bufrem (2018) point out the recitation by Aldo Barreto and his descendants of the authors: Levy, Bourdieu, Foucault, Wersig, Belkin, Wittgenstein, Lancaster, Morin, Habermas and Simon, in line with the authors identified in this research.

4 FINAL CONSIDERATIONS

This research applied the ABC indicators, in their absolute and normalized perspectives, to Aldo Barreto's direct descendant's network (supervised doctoral graduates) and indirect descendants (supervised doctoral graduates' students) formed by PQ fellowships active in 2018, as a methodological proposal and a new metric for academic genealogy studies.

Having retrieved and analyzed Aldo Barreto and his descendants' work, it was initially observed that both Aldo Barreto and his descendants published articles written, mostly, without

the presence of other researchers, including without their students and/or advisor, showing that the supervision were mainly characterized by scientific independence.

From the absolute ABC indicator values relative to the strength of common recited authors in the mentor-mentee relationship, it was possible to observe that, among the seven PQ fellows descended from Aldo Barreto, three from his first-generation supervision coupled with higher strength, showing a higher theoretical and methodological affinity; they are: Maria N. González de Gomez, Regina M. Marteleto and Carlos H. M. Almeida. In addition to these researchers, it is noteworthy that Aldo coupled (he has theoretical references in common) with all his PQ fellowship descendants, by at least one recited author, including the three from second-generation researchers, with emphasis on Icléia Thiesen, who coupled to Aldo with five common recited authors.

Still from the perspective of the first absolute ABC indicator, resulting from the strength of common recited authors, the intersection of the lists of authors recited by two researchers (advisor and student) describes their recitation dynamics and portrays part of the intellectual heritage, represented by the theoretical references, transmitted from Aldo Barreto to his first and/or second-generation descendants. In addition, as a methodological proposal, the ABC application pointed out the strength with which the researchers resorted to the recited authors who linked (coupled) to another researcher in the network. Thus, it was possible to portray the citing scientific identity of the analyzed genealogy network, through the most influential authors. In this sense, Pierre Bourdieu and Michel Foucault, as the most recited authors, become part of the scientific identity of this group of researchers as the main influencers.

Also noteworthy is the fact that Aldo Barreto is not present in any of the lists of authors recited by his students. Maria N. González de Gomez, supervisor of three PQ fellowship researchers, is present in the list of all her analyzed students' recited authors.

Regarding the researcher Maria N. González de Gomez and her students, the most fertile student in the academic genealogy network, it is possible to point out her own presence in the lists of recited authors who couple her to her descendants. The coupling relationship between the researcher and his advisee, José M. Jardim, stands out, as they are present in the list of authors who are couplers of both and thus provide a crossed ABC, that is, the researcher repeatedly cited the advisee in his work and vice versa.

The values of the absolute ABC indicator obtained from weighting the common recited authors by the recitation strength to these authors allowed to identify not only the common recitation dynamics between advisor and student, but also the strength of recurrence to the recited authors in the work of the analyzed researchers. In this context, the following stand out: Pierre Bourdieu (present in the reference lists of 6 out of the 8 analyzed researchers) and Michel Foucault (present in the reference lists of 5 researchers). It is noteworthy that both Bourdieu and Foucault were cited at the beginning of the academic genealogy chain, that is, by Aldo Barreto and remained recurrent in the works of most of his descendants. This result suggests that the theoretical basis of these descendants constitutes one of the intellectual inheritances pervaded in the supervision relation present in the analyzed academic genealogy tree.

The normalized ABC indexes allowed to contextualize the similarity between the theoretical references adopted by the researchers, by eliminating the influence of the size of the set of articles published by each researcher, which directly impacts the number of authors these researchers recite. In this scenario, the evidence of the theoretical and methodological proximity between Aldo Barreto and Maria N. González de Gomez, between A. Barreto and Regina M. Marteleto and between Maria N. González de Gomez and Icléia Thiesen was reinforced. However, based on the normalized ABC index, the similarity between the theoretical and methodological currents of Aldo Barreto and Carlos H. M. Almeida is no longer the third

strongest, as occurred in relation to the absolute ABC values, giving way to the proximity between Maria N González de Gomez and Icléia Thiesen (advisor and student) and between Aldo Barreto and Icléia Thiesen (advisor and academic granddaughter).

Thus, based on the results found in this study, Aldo Barreto's contribution to his generations of academic supervisions is considered to be mainly related to the autonomy of his descendants, as most of his articles were published individually and, in terms of theoretical influences, the following authors stand out: Bourdieu, Foucault, Belkin and Lévy, recurrently recited in the succession lineage of Aldo Barreto's academic genealogy network composed of PQ fellowship descendants.

Thus, from the results, the ABC method allowed to evaluate the strength of the theoretical and methodological similarities in Aldo Barreto's academic network of PQ descendants by identifying the strength and list of common recited authors by two researchers among whom there is an academic genealogy relationship, whether this proximity is weighted by the recitation strength to each recited author, whether it is normalized, by excluding the influence of the size of each researcher's work.

Continuing this research, further studies are suggested to investigate threshold values that signal the significance of the ABC index value strength between two researchers. This type of analysis will contribute to elucidate the debate regarding the significance of these indexes as a representation of the strength of theoretical and methodological proximity between the involved researchers, without disregarding the context and the epistemological specificities of the scientific field they operate.

Finally, it is pointed out that, given the expressiveness of the analyzed PQ fellows for Brazilian science, especially for the area of Information Science, describing the authors who most influenced their works and how these authors remain important in the theoretical-methodological basis of their academic lineages contribute to the understanding and diachronic analysis of the scientific development of the field and offer support for studies within the scope of history of science. This contribution is especially important when it comes to analyzing an exponent researcher such as Aldo Barreto, who participated in an outstanding way for the scientific advance and consolidation of Information Science.

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| 21

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