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GEOBOTANICAL CONDITIONS OF HABITATS OCCUPIED BY *Phalaridetum arundinaceae caricetosum gracilis* COMMUNITY IN THE MIDDLE WARTA VALLEY (CENTRAL POLAND)

Summary

The paper provides an assessment of habitat conditions of Phalaridetum arundinaceae caricetosum gracilis subassociation. Phytosociological research was conducted in a vegetation season of 2017 in the middle Warta, near Poznań, in the area with varied moisture and trophic conditions. Variety of flora, a botanical structure and a phytosociological one were assessed. Three soil opencasts were done within the area. Such properties as reaction, the content of total carbon and nitrogen, texture, soil density and its particle density, porosity, maximal hygroscopic capacity, water bond potentials of soil, readily and total available water were marked. In an investigated area, a subassociation of Phalaridetum arundinaceae caricetosum gracilis usually formed degraded barren. The crop as well as an economic value of species in the habitat were low. A systematic affiliation of syngenetic groups in an association of Phalaridetum arundinaceae and a subassociation of Phalaridetum arundinaceae caricetosum gracilis in the valley of Warta river was strongly connected with a percentage share of species which formed a variant of reed cane. In the researched area, Murshic soils in various in stages of mucking were a dominant soil habitat of a subassociation Phalaria arundinaceae caricetosum gracilis. In these soils, a peat-forming process had been stopped and replaced with decession of organic matter. A change of a soil-forming process was probably a result of a natural lowering of soil-ground water level, which had been triggered by an unfavorable water balance.
***Key words**: reed canary grass meadows, nature evaluation, analysis of flora*

WARUNKI GEOBOTANICZNE SIEDLISK ZAJMOWANYCH PRZEZ ZBIOROWISKO *Phalaridetum arundinaceae caricetosum gracilis* W DOLINIE ŚRODKOWEJ WARTY (ŚRODKOWA POLSKA)

Streszczenie

W pracy przedstawiono ocenę warunków siedliskowych podzespołu Phalaridetum arundinaceae caricetosum gracilis. Badania fitosocjologiczne przeprowadzono w sezonie wegetacyjnym 2017 w dolinie środkowej Warty w okolicach Poznania, na obszarze o zróżnicowanych warunkach wilgotnościowych i troficznych. Oceniono różnorodność szaty roślinnej, strukturę botaniczną i fitosocjologiczną. Na badanym terenie podzespół Phalaridetum arundinaceae caricetosum gracilis tworzył zazwyczaj zdegradowane nieużytki. Cechowały go niskie plony, a także mała wartość gospodarcza gatunków tworzących to zbiorowisko. Przynależność systematyczna grup syngenetycznych w zespole Phalaridetum arundinaceae i podzespole Phalaridetum arundinaceae caricetosum gracilis w dolinie Warty była ściśle powiązana z procentowym udziałem gatunków tworzących wariant szuwaru mozgowego. Na badanym terenie dominującym siedliskiem glebowym podzespołu Phalaria arundinaceae caricetosum gracilis były gleby torfowo-murszowe, wykazujące różne stadia zmurszenia. W glebach tych proces torfotwórczy został przerwany i zastąpiony decesją materii organicznej. Zmiana procesu glebotwórczego była przypuszczalnie wynikiem naturalnego obniżenia się poziomu zwierciadła wody glebowo-gruntowej, co spowodowane było prawdopodobnie niekorzystnym bilansem wodnym.
***Słowa kluczowe**: łąki mozgowe, waloryzacja przyrodnicza, analiza flory*

1. Introduction

High yielding reed canary grass which forms an association of *Phalaridetum arundinaceae* KOCH 1926 n.n.) LIBB. 1931, is very popular throughout the country and one of the most widespread associations of *Phragmition*. Sometimes it covers significant areas, even up to several hectares. An association of *Phalaridetum arundinaceae caricetosum gracilis* subass. nova [21], is usually found in small groups in permanently moist habitats, in various parts of river valleys, in floodplains, oxbow lakes and valley depressions. Reed of this subassociation is found in the lowest parts of river valleys, often along river banks, ditches, ponds, around water reservoirs, usually in wet and moist habitats. Eutrophic soils – mainly peats with various state of decay – provide the best conditions for its optimal growth [23]. Both *Phalaridetum arundinaceae typicum* and *Phalaridetum arundinaceae caricetosum gracilis* subassociation are vital in the environment protection [20, 24]. Marshy areas, which are often occupied by the discussed community, are susceptible to natural and anthropogenic dehydration which may significantly reduce their natural values. A sudden change of moisture conditions initiates a mucking process and many more changes in chemical and physical properties of a soil habitat. According to Grootjans and Wołejko [18], in over 80% of original peatlands. Reasons for such changes are hydrological disturbances triggered by climate conditions or an anthropic activity. According to Brandyk et al. [3], in extreme cases, peat habitats may totally disappear. Degradation changes in soils is connected with floristic changes. A strong relationship between habitat conditions and species composition was found inter alia in a paper by Kiryluk [32]. According to this author, such changes occur most rapidly in post-marshy habitats which emerge after dehydration of marshes and other wetlands which is conducted in order to prepare them for agriculture use and which results in degradation not only of the ecosystems' natural values but also – in a longer perspective – of an economic value of green growth. This opinion is supported by other authors, who claim that changes in soil management such as ceasing grazing or mowing result in irreversible transformations [1, 7]. This view is also supported by Gamrat et al. [13]. In their opinion, it is connected with a fast reaction of flora to changing habitat conditions. Niedźwiecki et al. [42] list such: landscape features, changing hydrological conditions, regular flooding, various soil conditions and anthropological transformations caused by changing human's management.

A role of management's character with grasslands in maintaining their biodiversity is also emphasized by Lorens [38]. According to the author, mowing and grazing play an important role in the endurance of such communities and in maintaining their biodiversity. A necessity to protect meadows is emphasized by numerous authors [36, 39]. Lorens [38] notices that only a part of meadow and reed communities is under protection, despite the fact that lots of them extinct gradually and therefore, rare and endangered plants are vanishing throughout the whole country. The author also suggests that learning the state and dynamic tendencies of these communities is vital for their survival both in protected areas and outside of them. *Phalaridetum arundinaceae* is an example of such a valuable phytocenoses. It protects and forms a landscape - as an ecological filter, it absorbs much of biogens from watercourses, it has a structure forming role, and protects soils from wind and water erosion, which has been emphasized inter alia by Grzelak [21], Grzelak et al. [22], Kryszak et al. [37]. The aim of this paper was an assessment of geobotanical conditions of *Phalaridetum arundinaceae* habitat in selected areas of middle Warta valley.

2. Object and methodology

2.1. Phytosociological research

Floristic research was conducted in representative groups of *Phalaridetum arundinaceae* association with Braun- Blanquets' method [4]. Phytosociological relevés were ordered in accordance with rules accepted in phytosociology. On the basis of the analysis of a floristic composition, an association of reed canary grass and a lower unit of *Phalaridetum arundinaceae caricetosum gracilis* was defined within, which allowed for the determination of a state of reed's diversification. In the association, the following parameters were marked: number of species, categorical frequency and a covering index, whereas in a subassociation: species characteristic in the association and distinctive for a *typicum* subassociation.

2.2. Soil science research

Soil profiles which represent the research area were classified as Murshic Histosols [28] (*In Polish – gleby organiczne murszowe*) [49]. Samples of intact and breached structures were collected from each of their genetic horizons and the following properties were marked: texture (with a sewing method for sand and a aerometric method for silt and clay) after dispersion with a sodium hexametaphosphate [40], particle density (with a picnometric method in mineral horizons [40] and with Zawadzki's formula in mineral and organic horizons) [43], soil's density – with Nitzsh's vessels of 100 cm^3, total porosity – determined on the basis of particle density and dry soil density [52], calcination loss after being burnt at 550^{o}C [40], maximum hygroscopic capacity (moisture at pF=4.5) – in a vacuum chamber at a negative pressure of 0,8atm and with a saturated K2SO4 solution, water bonding potential of a soil – with the method of Richard's pressure chambers [35], total and readily available waters – calculated on the basis of pF, content of carbon and total nitrogen – with Vario Max CNS analyzer and pH – potentiometrically. All the published results are averages from five replications. Morphological structure and taxonomic classification were presented in accordance with Polish Soil Classification (SgP) [49].

3. Results and discussion

3.1. Floristic research

An investigated association of *Phalaridetum arundinaceae* was classified as association *Magnocaricion*, order *Phragmitetalia.*

C l a s s i f i c a t i o n s y s t e m

Class: *PHRAGMITETEA* R.TX. et PRSG. 1942,
Order: *PHRAGMITETALIA* W. KOCH 1926 (Syn. *Magnocaricetalia* PIGNATTI 1953),
Association: *MAGNOCARICION* KOCH 1926 (KOCH 1926 n.n.) LIBB. 1931,
Association: *Phalaridetum arundinaceae* (KOCH 1926 n.n.) LIBB. 1931**,**
Within *Phalaridetum arundinaceae association, a subassociatio of Phalaridetum arundinaceae caricetosum gracilis* was found.

A subassociation affiliation of a *Ph. arundinaceae caricetosum gracilis r*esulted from the presence of characteristic species (Table 1). In *Magnocaricion* seven species were distinguished with S = I-V and D = 0,6-6910,9. Reed cane grew both in one and two layers. Sometimes it formed aggregations of *Phalaridetum arundinacea* with a little addition of other species. *Phalaridetum arundinacea* (5th level of constancy and high cover index) and *Poa palustris* were species characteristic and identifying this association (Table 1).

In terms of physionomy, *Phalaridetum arundinaceae caricetosum gracilis* subassociation was usually maximum 1m high. Layers of reed with a significant share of *Carex gracilis* were compact and with high constancy S = IV and D = 1211.6. Species characteristic to this subassociation were also: *Carex riparia* (S = III, D = 306.0) and *Lythrum salicaria* (S = II, D = 32.2). There were only 27 species in the subassociation, many of which preferred mainly highly moisturized locations (Table 2).

Table 1. Systematic values of *Phalaridetum arundinaceae* syngenetic groups in the Warta river valley
Tab. 1. Wartości systematyczne grup syngenetycznych Phalaridetum arundinaceae w dolinie Warty

Syngenetic group	Number of species	Phytosociological constancy	Cover index
Magnocaricion	7	I-V	0.6-6910.9
Phragmition	5	I-III	0.4-17.5
Phragmitetalia, Phragmitetea	5	I-V	0.7-238.6
	5	I-IV	0.8-371.4
Molinietalia	7	I-IV	0.2-386.7
Arrhenatheretalia	8	I-III	0.7-170.0
Molinio-Arrhenatheretea			
Accompanying species	13	I-III	0.4-658.5

Source: own study / Źródło: opracowanie własne

Table 2. Synthesis of subassociations within the *Phalaridetum arundinaceae*
Tab. 2. Synteza podzespołów w obrębie Phalaridetum arundinaceae

Species	*Ph. ar. caricetosum gracilis*
Number of relevés	21
Sp. charact. to the associacion and differential species for the subass. typicum	
Phalaridetum arundinacea	V 1841.7
Poa palustris	II 85.8
Differential species for the subass. *caricetosum gracilis*	
Carex gracilis	IV 1211.6
Carex riparia	III 306.0
Lythrum salicaria	II 32.2
Phragmition	
Glyceria maxima	I 4.5
Schoenoplectus lacustris	I 3.8

Source: own study / Źródło: opracowanie własne

3.2. Soil science research

Epipedons of the researched soils were formed from muck, with thickness of 0.31-0.48 m. Level of mucking of these horizons was varied, which was also visible in the differentiation of field features in their structures. Below, there were peat deposits with *hemic* (profiles 1 and 2) and *sapric* (profile 3) level of decomposition and thickness of 0.83-1.25 m. Constant ground water level was located deep, which is a prove for an advanced process of dehydration of these soils. From a soil scientific and a phytosociological point of view, this may be treated as degrading changes. In a dozen of years, they may lead to the disappearance of these deposits and deterioration of a natural value and green growth [48]. Bottoms of all the researched soils were formed from sands. Their texture is presented in detail in Table 3. In terms of the listed hazards, the presence of such a floor is strongly unfavorable as it may accelerate dehydration as well as soil degradation and the disappearance of marsh flora.

Morphological structure of all the researched soils allows for their classification as an order of organic soils and a type of organic mucky soils. Heterogeneity of the level of decomposition of peat horizons was a basis for the distinguishing of two subtypes: organic hemic and mucky soils (profiles 1 and 2) and saphric and mucky soils (profile 3). A maternity rock of all the analyzed soils was low peat.

Properties of organic soils are determined mainly by the content and quality (a botanical composition, a level of decomposition) of organic matter [12, 27]. It is also emphasized in terms of peat's properties (mainly a maternity rock of the deposits) by inter alia, Grover and Baldock [19] and Ilnicki [27]. In mucked epipedons, the content of organic matter oscillated from 321. 7 to 523.1 $g{\cdot}kg^{-1}$ (Table 4).
These figures were close to the ones presented by other authors for soils of similar genetics and formed from similar maternity materials [45]. In peat horizons located underneath, a connection between a level of decomposition and a content of organic matter was visible (Table 4). In strongly decomposed *sapric* peats (profile 3), a content of organic matter was 602.4 (Oa1) and 664.7 ($g{\cdot}kg^{-1}$) (Oa2) and was much lower than in *hemic* peats (profiles 1 and 2). The content of organic matter in these deposits oscillated from 702.1 (Oe1, prof. 1) to 856.8 (Oe3, prof. 2) ($g{\cdot}kg^{-1}$). Similar relations had been proven in previous individual research by Gajewski, et al. [10] and other authors [45]. The content of organic matter was low in a sandy bed: 4.1-5.5 ($g{\cdot}kg^{-1}$).

In all the profiles, a content of total nitrogen in mucks was lower that in peats located underneath. In mucks it oscillated from 19.18 (prof. 1) to 21.14 ($g{\cdot}kg^{-1}$) (prof. 3) whereas in peats: from 20.97 (Oe2, prof. 1) to 28.94 ($g{\cdot}kg^{-1}$) (Oe1, prof.2) (Table 4). Similar values of this element were also observed in the previous research [11, 29]. However, in the listed papers, a content of total nitrogen was also much lower when compared to the mucked epipedons located underneath. A drop in the content of nitrogen in mucks, when compared to peat, probably results from the mineralization of organic matter which occurs in the process of mucking. Similar conclusions were drawn by Sowiński et al. [51]. More significant content of total nitrogen in muck than in peat was reported by Ilnicki [27].

The reaction of the examined soils was medium acidic, in accordance with the classification provided by Okruszko [44]. Both in mucks and in peats, pH oscillated from 5.2 to 6.2 (Table 4). The data fit into the scope provided in the literature [27]. Orzechowski et al. express the opposite opinion [45]. PH of peats was higher than pH of mucks. The values might have been a result of a seasonal (in early spring) retention of soil-ground water. Kalisz et al. [30] provide information about a acidifying character of a mucking process which might be helpful in the understanding of this phenomenon. Clark et al. [6] had similar observations, as well as Eimers et al. [8].

Table 3. Texture of mineral horizons of the soils studied
Tab. 3. Uziarnienie poziomów mineralnych badanych gleb

Profile numer	Horizon	Depth (cm)	Percent of fractions (mm)						Texture acc. PTG 2009
			2,0-0.1	0.10-0.05	0.05-0.02	0.02-0.005	0.005-0.002	<0.002	
1	Cg	>155	85	6	6	2	0	1	S
2	Cg	>160	88	4	5	1	1	1	S
3	Cg	114-135	85	7	4	2	1	1	S

Explanation: S – sand,
Source: own study / Źródło: opracowanie własne

Table 4. Basic physical and chemical properties of the soils studied
Tab. 4. Podstawowe właściwości fizyczne i chemiczne badanych gleb

Profile number	Horizon	Depth (cm)	Particle density ($Mg \cdot m^{-3}$)	Bulk density ($Mg \cdot m^{-3}$)	Total porosity (%v/v)	Organic matter ($g \cdot kg^{-3}$)	pH in 1M KCl	Total nitrogen ($g \cdot kg^{-3}$)
1	M	0-48	2.15	0.64	70.23	365.4	5.2	19.18
	Oe1	48-72	1.78	0.41	76.97	702.1	5.5	21.74
	Oe2	72-120	1.69	0.38	77.51	781.1	5.7	20.97
	Oe3	120-155	1.66	0.42	74.70	810.2	6.1	21.22
	Cg	>155	2.65	1.58	40.38	5.4	5.8	0.20
2	M	0-35	1.98	0.51	74.24	523.1	5.6	27.85
	Oe1	35-95	1.68	0.29	82.74	789.8	5.8	28.94
	Oe2	95-140	1.65	0.31	81.21	821.3	6.1	28.45
	Oe3	140-160	1.61	0.42	73.91	856.8	6.2	28.21
	Cg	>160	2.65	1.65	37.74	4.7	5.6	0.14
3	M	0-31	2.20	0.70	68.19	321.7	5.3	21.14
	Oa1	31-73	1.89	0.52	72.49	602.4	5.6	25.38
	Oa2	73-114	1.82	0.48	73.62	664.7	5.5	28.26
	Cg	114-135	2.65	1.57	40.75	4.1	5.7	0.17

Source: own study / Źródło: opracowanie własne

In the researched soils, values of particle density (Table 4) were characteristic to deposits of a similar origin [12]. In epipedons, particle density oscillated between 1.98 and 2.20 ($g \cdot kg^{-1}$). It was higher than in the peats underneath where the values of an analyzed property were between 1.61 (Oe3, prof. 2) and 1.89 (Oa1, prof. 3) ($g \cdot kg^{-1}$). Gebhardt et al. [15] obtained similar values for this trait in organic soils. In a mineral bed of all the researched soils, particle density was 2,65 $g \cdot kg^{-1}$. Values of bulk density was much more diversified. In epipedons, probably as a result of a mucking process and consequently – decession of organic matter and structural changes, bulk density was higher than in the peats underneath. In top horizons, density oscillated from 0.51 to 0.70 ($g \cdot kg^{-1}$) (Table 4). Such values were marked in profiles 2 and 3, respectively. In peats, density oscillated between 0.29 (Oe1, prof. 2) and 0.52 (Oa1, prof. 3). These differences were especially visible when comparing the density of mucks and the density of *hemic* peats. A grainy structure of mucks strongly contrasted with their fibrous, spongy structure. Such an effect of mucking was also observed by some authors [9, 27]. A similar level of the discussed feature in soils with a similar origin and organic matter content was found by Berglund and Berglund [2]. The authors conducted an observation similar to the one presented in this paper – the lower the level of decomposition of organic deposits, the lower their density was. A very low density of soils was also reported by Caron et al. [5].

A level of the discussed feature in a mineral bed oscillated from 1.57 to 1.65 ($g \cdot kg^{-1}$). A low level of soil's density resulted in high total porosity (Table 4). In epipedons, this trait oscillated between 68.19 and 74.24%. It was higher in peats: 72.49 (Oa1, prof.3) – 82.74% (Oe1, prof.2). Similar values of porosity were reported by Hallema et al. [25] whereas in the research by Giedrojć [16], porosity of mucks and peats was lower. A drop in total porosity in mucks when compared to maternity peats was confirmed by numerous researchers [24, 27, 41]. The main reason for it was the change of a spongy or fibrous structure of peats into an aggregate or grainy structure of mucks.

Retention values are an important characteristic of a soil in terms of its air-water and habitat conditions. A maximal water capacity was by about 1-4% lower than total porosity (Table 5), which had already been observed in individual researches [12] and in works by other authors [27]. Soil's moisture at a field water capacity (pF =2.0) is an important water trait, with a special relevance when the availability of water for plants is concerned (Table 5). In mucks it oscillated from 47.11% (M, prof.1) to 52.88% (M, prof. 2), in peats - from 51.11 (Oe3, prof.2) to 64.12% (Oe1, prof. 2). A significant difference in the level of this trait in mucks and peats probably resulted from unfavorable changes in differential porosity which had taken place in a mucking process of top horizons. Similar observations were made by [17, 33, 34]. A content of water at moisture corresponding with the point of production water (pF = 3.7) was high (Table 5). In epipedons they oscillated from 26.04 (prof. 3) to 32.58 (prof. 1), in peats they were usually higher: from 31.02 (Oe3, prof.2) to 40.22 (Oe1, prof. 2). What was also high (8,01 - 24,07%) in organic horizons, that was moisture which corresponded with a wilting point (pF = 4.2) (Table 5). Values of this trait were usually higher in peats than in mucks. The research confirmed a trait of organic soils which had already been defined, i.e. high maximal hygroscopic capacity (Table 5). Such specification of these deposits was observed inter alia by Gajewski et al. [12], Hewelke et al. [26], Kechevarzi et al. [31], Owczarzak et al. [46]. Among the investigated soils, the trait was especially visible in peats, which had also been observed by Smólczyński et al. [50] according to whom the content of strongly bonded water grew along with the level of decomposition of peats. High content of strongly bonded water is an unfavorable characteristic as it significantly limits an amount of available water for most of the plants. Owczarzak et al. [46] suggest that the presence of such water may moderate dehydration of hydrogenic soils and result in disappearance of valuable habitats. For the production of a floral biomass, retention abilities in terms of readily and total available water is the most important water trait of a soil (Table 5). In top horizons, the lowest readily available water was observed in profile 1, whereas the highest – in profile 3. These were 14.53 and 24.83%, respectively. In peats it was usually slightly higher: from 18.97 (Oe1, prof. 1) to 26.48% (Oe2, prof. 2). Unfavorable impact of a mucking process on retention abilities of organic soils was observed inter alia by Gawlik and Szajda [14]. The TAW, due to the large amount of water that could be retained in the area of pF 3.7-4.2, was sometimes even twice as high as RAW.

Table 5. Soil water potentials and the total and readily available water in the soils studied
Tab. 5. Potencjał wody glebowej oraz potencjalna i efektywna retencja użyteczna badanych gleb

Profile number	Horizon	Depth (cm)	Water capacity at pF: (%v/v)					RAW	TAW
			0.0	2.0	3.7	4.2	4.5	2,0-3,7	2,0-4,2
1	M	0-48	69.08	47.11	32.58	15.06	6.07	14.53	32.05
	Oe1	48-72	75.02	56.09	37.12	21.11	12.99	18.97	34.98
	Oe2	72-120	76.07	57.33	35.41	20.77	11.02	21.92	36.56
	Oe3	120-155	72.11	56.17	34.08	18.44	10.22	22.09	37.73
	Cg	>155	38.41	8.09	3.55	2.04	1.07	4.54	6.05
2	M	0-35	72.18	52.88	29.87	12.03	5.66	23.01	40.85
	Oe1	35-95	80.17	64.12	40.22	24.07	14.87	23.9	40.05
	Oe2	95-140	78.47	63.77	37.29	21.01	12.33	26.48	42.76
	Oe3	140-160	71.08	51.11	31.02	16.02	9.88	20.09	35.09
	Cg	>160	35.54	7.08	2.99	1.74	0.87	4.09	5.34
3	M	0-31	66.08	50.87	26.04	8.01	4.88	24.83	42.86
	Oa1	31-73	70.12	55.41	32.21	20.12	13.07	23.2	35.29
	Oa2	73-114	71.08	62.12	37.15	21.30	12.54	24.97	40.82
	Cg	114-135	36.08	7.50	3.04	1.80	1.22	4.46	5.7

Source: own study / Źródło: opracowanie własne

4. Summary

In an investigated area, a subassociation of *Phalaridetum arundinaceae caricetosum gracilis* usually formed degraded barren. The crop as well as an economic value of species in the habitat were low.

A systematic affiliation of syngenetic groups in an association of *Phalaridetum arundinaceae* and a subassociation of *Phalaridetum arundinaceae caricetosum gracili*s was strongly connected with a percentage share of species which formed a variant of reed cane.

In the researched area, mucky soils in various stages of mucking were a dominant soil habitat of a subassociation *Phalaria arundinaceae caricetosum gracilis*. In these soils, a peat-forming process had been stopped and replaced with decession of organic matter. A change of a soil-forming process was probably a result of a natural lowering of soil-ground water level, which had been triggered by an unfavorable water balance.

Epipedons were formed from muck underlaid by maternity peats in various stages of decomposition. An interrupt of a marshy process and initiation of a decession phase in an organic matter were reflected in the results of the analyzed properties. This change resulted in a drop in the content of organic matter in mucks when compared to the peats underneath. What fallowed that was a deterioration of most of other features in epipedons. It was proven that the mucking process led to a growth in density and a drop in total porosity and most often – in retention abilities. Initiated mucking process may cause total disappearance of hydrogenic soils (and habitats of marshy flora) in several decades, actions aimed at renaturisation of these valuable ecosystems should be taken right now. Re-establishing of air and water conditions which limited mucking seems crucial.

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