

THE EVOLUTION OF GALAXIES IN CLUSTERS. II. THE GALAXY CONTENT OF NEARBY CLUSTERS

HARVEY BUTCHER

Kitt Peak National Observatory*

AND

AUGUSTUS OEMLER, JR.

Yale University Observatory

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ABSTRACT

We have studied the structure and galaxy content of most nearby rich clusters of galaxies, using new data as well as those already in the literature. Devising a simple numerical indicator of the central concentration of clusters, we find it to be strongly correlated with the spiral galaxy content of the clusters. Only the least-concentrated clusters show an appreciable content of spiral galaxies, in strong contrast to the distant clusters described in our previous paper. *If* we are observing nearby clusters at every stage of dynamical evolution, these results strongly support the hypothesis of an efficient stripping mechanism in collapsed clusters.

Subject headings: galaxies: clusters of — galaxies: evolution — galaxies: structure

I. INTRODUCTION

It has been known for many years (Abell 1965; Oemler 1974) that the structure of clusters of galaxies is correlated with their galaxy content. Irregular, formless clusters have a galaxy population similar to that of the "field," while regular, centrally concentrated clusters contain, in their cores, only elliptical and S0 galaxies. In the first paper of this series (Butcher and Oemler 1978) we reported that the two most prominent distant ($z \gtrsim 0.4$) centrally concentrated clusters had, in contrast to nearby objects, a large population of galaxies with the colors of spirals. The simplest interpretation of this observation is quite startling: namely, that there has been strong evolution of galaxy populations during the last third of the age of the universe.

Because this result is so contrary to present views about galaxy evolution, it is clearly important that all of the steps leading to this conclusion be well established. In subsequent papers we shall present more data on the properties of distant clusters; but it is equally important to demonstrate that the relation between structure and content described above is exact and universal among nearby clusters. Previous work on this phenomenon has only been qualitative, and in this paper we present a more quantitative demonstration.

This paper is in three parts. In § II we develop a quantitative parameter describing the central concentration of a cluster and determine its value for a moderately large sample of clusters. In § III we deter-

mine the galaxy content of these same clusters, and in § IV we discuss the significance of our findings.

II. CLUSTER STRUCTURE

We wish to demonstrate that the galaxy content of a cluster depends on whether the cluster is irregular and unconcentrated or regular and centrally condensed. Concentration is an easier thing to quantify than degree of regularity, and it is that quality which we shall investigate. There are many possible ways to measure concentration, but any good measure must be independent of cluster size, richness, mean density, and distance. Although more sophisticated formulations are possible, we have found the following measure to be quite satisfactory. Let us define R_n to be the radius containing n percent of the projected galaxy distribution. Then we define the central concentration,

$$C = \log (R_{60}/R_{20}). \quad (1)$$

One possible difficulty with this definition is the use of the quantity R_n , which assumes that the cluster population converges to a finite total. Work done in recent years on the covariance function of galaxy distributions suggests that the influence of a cluster extends to radii of several tens of megaparsecs. Fortunately, this very extended halo is of no consequence to the central cluster itself, which, many studies have demonstrated, has a definitely bounded galaxy distribution, with limiting radii of typically 3-6 Mpc (see Bahcall 1977).

A more practical difficulty is that the outer bounds of most clusters are lost among the fluctuations of the background and cannot be directly determined. One must therefore extrapolate, for which we have used a

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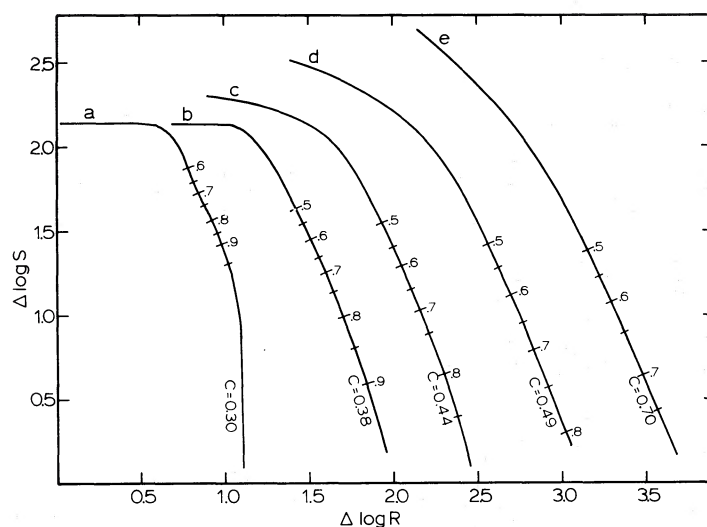


FIG. 1.—Projected galaxy density profiles of model clusters. Indicated along each profile are the fractional galaxy contents within that radius.

series of numerical models of clusters calculated by Dr. Sverra Aarseth. These unpublished models have been only described briefly in Oemler (1973); but they are very closely related, except for the number of mass points, to those of White (1976). Projected mass distributions for these models at various evolutionary stages are presented as curves *b–e* of Figure 1. All represent collapsed clusters. Before the time of collapse, the mass distribution is completely dependent on initial conditions and the Aarseth models are not suitable. Curve *a*, which represents an uncollapsed cluster, has been determined empirically in a manner to be described later. Along each curve are indicated the radii containing various fractions of the total cluster galaxy content. The profiles presented below typically require extrapolation outward from R_{65} or R_{80} . It is a happy accident that *C* is quite insensitive to extrapolations of this size.

We have gathered data on as many rich clusters of galaxies as possible. In order to be included, a cluster must either have multicolor photometry available for it or must be near enough to permit its galaxies to be reliably classified on the photographic material to which we had access. The clusters we have studied, and their redshifts, are listed in the first two columns of Table 1. Because a cluster's inclusion depended on the availability of suitable observational material, this is in no sense a complete sample. However, of the objects in Abell's (1958) catalog, it does include both of the distance class 0 clusters, 11 of the 19 distance class 1 clusters, as well as eight more distant clusters. Three nearby clusters were excluded despite the availability of suitable material. The cluster A2634 is in such a confused region of the sky that it was impossible to adequately determine its structure. Both A2162 and A2666 appear to have been included in Abell's catalog by mistake. Neither is large enough or rich enough to be considered a rich cluster of galaxies. We have limited

this survey to rich clusters—meaning, roughly, those with at least as many galaxies as the Virgo cluster. Poor groups seem to have a much wider variety of properties than rich clusters and probably would not show the strong correlation of structure and content which we shall demonstrate below.

Where galaxy counts of satisfactory quality already existed for a cluster, we have not repeated them. In the other clusters, galaxies were counted in rings about a center determined from strip counts. We have used plates (usually IIIa-J) taken with the Palomar 48 inch (1.2 m) Schmidt telescope, when available, or else the red prints of the Palomar Observatory Sky Survey. The profile of the Virgo cluster was obtained from the distribution of galaxies in the Second Reference Catalog (hereafter SRC; de Vaucouleurs, de Vaucouleurs, and Corwin 1976), with $B_T \leq 13.0$ and $b > 40^\circ$. In a few of the more distant clusters, objects were counted down to the plate/print limit; but in the nearer clusters, a scale was used to set a limiting angular size of the galaxies counted. The resulting profiles are presented in Tables 2 and 3. In column (1) are listed the outer radius of each ring in arcmin. Subsequent columns give, for each cluster, the galaxy density, ρ , per square degree after subtraction of background, and the fraction f of the total cluster population contained within that radius. The galaxy background density, determined from the outer rings, and the estimated visual limiting magnitude are given at the end of each cluster's listing.

As has been the almost universal practice, we have assumed that all of our clusters are circular, in spite of unambiguous evidence that at least some are considerably flattened. We can only hope, probably justifiably, that this has not grossly affected our determinations of *C*.

In examining the profiles obtained from the literature and from our counts, it was strikingly apparent

TABLE 1
CLUSTERS STUDIED

CLUSTERS	Z	C	Source	%Sp	Types
Coma Cl.	0.0230	0.55±.02	1,2	7±2	*
Hercules Cl.	0.0360	0.30±.04	2,*	47±5	*
Perseus Cl.	0.0183	0.59±.04	3	10±3	*
Virgo Cl.	0.0038	0.37±.05	*	34±9	*
Abell 154	0.0652	0.65±.05	4,5	15±15	
Abell 168	0.0449	0.64±.04	5	19±15	
Abell 194	0.0181	0.48±.06	2,*	15±4	*
Abell 262	0.0168	0.30±.03	*	42±7	*
Abell 400	0.0231	0.45±.03	2,*	14±2	*
Abell 539	0.0267	0.59±.03	2	8±3	*
Abell 779	0.0200	0.39±.05	*	12±4	*
Abell 1060	0.0094	0.48±.05	*	16±3	*
Abell 1228	0.0334	0.30±.04	2,*	53±8	*
Abell 1314	0.0335	0.55±.05	2	11±3	*
Abell 1367	0.0205	0.30±.03	2,6	50±6	*
Abell 1413	0.1427	0.50±.03	2,7,8	12±8	
Abell 1689	0.1747	High		<15	
Abell 2197	0.0303	0.29±.03	2,*	31±5	*
Abell 2199	0.0312	0.52±.04	2,9	20±4	*
Abell 2255	0.0763	0.51±.03	10	20±5	
Abell 2256	0.0594	0.59±.04	5	9±6	
Cl0024+1654	0.394	0.50±.04	11	50±10	
3C 295	0.4619	0.58±.04	11	59±15	

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|-----------------------------------|-------------------------------|
| 1. Omer, Page and Wilson (1965) | 7. Noonan (1972) |
| 2. Oemler (1974) | 8. Austin and Peach (1974) |
| 3. Bahcall (1974) | 9. Bahcall (1973) |
| 4. Baier (1977) | 10. Baier (1976) |
| 5. Dressler (1976) | 11. Butcher and Oemler (1978) |
| 6. Rudnicki and Baranowska (1966) | * This paper |

TABLE 2
CLUSTER PROFILES

R'	<u>Hercules</u>		<u>A194</u>		<u>A262</u>		<u>A400</u>		<u>A779</u>		<u>A1060</u>		<u>A1228</u>		<u>A2197</u>	
	ρ	f	ρ	f	ρ	f	ρ	f	ρ	f	ρ	f	ρ	f	ρ	f
2.5	603	.01	327	.01									119	.02	334	.02
5.0	176	.02	204	.04	102	.01	219	.01	193	.04	268	.03	180	.07	89	.03
7.5	310	.05	217	.08			232	.03					156	.13	150	.07
10.0	368	.10	170	.13	71	.04	132	.05	71	.08	161	.07	43	.17	72	.10
15.0	356	.23	70	.19	92	.10	131	.10	111	.20	112	.13	101	.35	132	.26
20.0	256	.37	71	.27	95	.18	145	.18	62	.29	65	.18	139	.53	97	.42
25.0	272	.56	21	.30	96	.29	62	.22	86	.45	39	.21	23	.73	79	.58
30.0	99	.64	60	.42	43	.34	75	.29	27	.50	35	.25	61	.98	67	.75
35.0	50	.69	30	.47	73	.46	46	.33	24	.57	21	.27	<10		38	.86
40.0	75	.78	12	.46	92	.63	42	.38	28	.65	11	.29			22	.94
50.0	81	1.00	26	.63	22	.72	40	.49			29	.39			≤5	
60.00	≤15		7	.70	8	.77	27	.57	7	.77	24	.49				
70.0			≤2		18	.89	19	.65			17	.58				
80.0					21	1.00	11	.70	2	.82	11	.65				
90.0					≤2		≤4				7	.69				
background/ V_{lim}	130/19.0		40/18.2		36/18.2		25/17.8		36/18.1		7/16.6		64/18.6		33/18.1	

TABLE 3
VIRGO CLUSTER PROFILE

R° (1)	ρ (2)	f (3)
1.....	2.190	0.07
2.....	2.400	0.31
3.....	0.720	0.43
4.....	0.960	0.65
5.....	0.390	0.77
6.....	0.280	0.86
7.....	0.105	0.91
8.....	0.043	0.93
10.....	0.011	0.95
12.....	0.024	0.97
Background/ V_{lim}	0.042/12.3	

that the profiles of the most irregular appearing clusters were all very similar and much less concentrated than even the earliest collapsed Aarseth model. A composite profile, constructed from the Hercules cluster, A262, A1228, A1367, and A2197, is presented as a curve *a* of Figure 1. This profile, for which $C = 0.30$, is very similar to that of a uniform density sphere ($C = 0.27$), except for a "soft" outer boundary. This curve is included merely for comparison purposes, since, as may be seen from Figure 1, the mass distribution converges so rapidly that no extrapolation was necessary in any of the clusters.

Using the profiles in Figure 1 to extrapolate our data, we obtain the cumulative cluster contents, $f(R)$ presented in Tables 2 and 3. From these and from the published data cited in column (4) of Table 1, we calculate the concentration values presented in column (3) of the same table. The uncertainties have been calculated assuming Poisson fluctuations about the true time-averaged cluster distribution. One cluster, A1689, was too distant for us to do galaxy counts using our available material. However, inspection shows that it is obviously quite centrally concentrated, and we shall hereafter assume that its concentration is typical of the concentrated clusters.

III. GALAXY CONTENT

Because the galaxy content of spiral-poor clusters varies with radius, we must be careful to determine it in a consistent manner. For the same reasons of distance, richness, and size independence which guided our choice of concentration parameter, we shall always determine galaxy content within a fractional radius R_n . The 30% radius, R_{30} , appears to be a good choice: smaller samples would have large statistical uncertainties; larger samples would include some of the spiral-rich envelope found even in spiral-poor clusters, and would dilute the cluster-to-cluster population differences. Since populations are also slightly dependent on the absolute magnitudes of the galaxies, we shall always determine them to a limiting magnitude about 4 mag fainter than the brightest cluster member.

Fifteen of the clusters in Table 1, those marked with asterisks in column (6), are close enough for us to

determine the galaxy content directly. We have classified galaxies using the best available material, which included KPNO 4 m plates for five of the clusters, Palomar 48 inch (1.2 m) Schmidt plates for eight of the clusters, and the ESO/SRC Southern Sky Survey transparencies for one. In Virgo, classifications are taken from the SRC. Column (5) presents the percent spirals in each cluster, with the uncertainties calculated assuming Poisson statistics.

The remaining clusters are too distant for us to classify their galaxies by inspection. In these, as in the high-redshift clusters in our previous paper, the types of galaxies can only be inferred from their colors. To do this we shall work backward, first constructing the expected color distributions of various galaxy populations and then comparing the observed cluster color distributions with them.

As a first approximation we may consider all galaxy populations as belonging to one of two types: spiral-rich and spiral-poor (see Oemler 1974). Spiral-poor populations, as we have said earlier, are found in the cores of at least some concentrated clusters, while spiral-rich populations are found everywhere else: in the halos of the same clusters, in unconcentrated clusters, and in the "field." Typical proportions of spirals/S0's/ellipticals are 15/50/35 in the former and 55/30/15 in the latter.

Among spiral-poor populations there is adequate photometry of only the Coma and Perseus clusters. In Coma, a sample approximating in both area and brightness that which we need is represented by the galaxies in Zwicky *et al.*'s (1961–1968) central 0.5 field. There exists almost complete *BV* photometry of this field by Sandage (1972), Weedman (1975), and from the SRC. A comparable sample in Perseus has photometry by Weedman (1975) and from the SRC.

The color distributions in the two clusters are similar in shape, but that of Perseus is shifted to the red of Coma's by 0.18 mag. This is a quite reasonable amount of interstellar reddening for Perseus's galactic latitude (-13°), and we have no qualms about correcting the Perseus colors by this amount. The results, k corrected by a further -0.06 mag, are presented in Figure 2, where E's occupy the shaded area, S0's the hatched area, and spirals the remainder. The ellipticals and S0's have identical, very narrow distributions; the one blue elliptical is NGC 1275, a very peculiar object. There are very few spirals, and they are spread out, as expected, over a wide color range to the blue of the E's and S0's.

Unfortunately, we do not have comparable photometry of a spiral-rich cluster like that in Hercules, and we will have to construct the expected color distribution from photometry of field galaxies. The data we have to work with are summarized in Figure 3, which presents the color distributions of the 1083 galaxies in the SRC with total $B - V$ colors. These are mostly field galaxies; however, also plotted for each morphological type are $\langle B - V \rangle$ and $\sigma(B - V)$ for galaxies in A262, A1367, and the Hercules, Perseus, Virgo, and Coma clusters. (There were insufficient irregulars to form a meaningful average.) There appears to be no

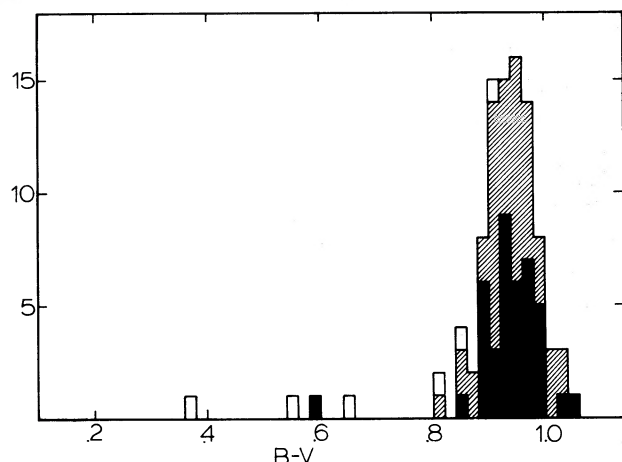


FIG. 2.—Corrected color distribution of galaxies within R_{30} of the Coma and Perseus clusters. *Filled area*, ellipticals; *hatched area*, S0's; *open area*, spirals.

significant difference in the color distribution of galaxies of a given morphological type in and out of clusters.

To construct a population like that of a spiral-rich cluster, we begin with galaxies brighter than $B_T = 13.0$ in the vicinity of, but outside the core of, the Virgo cluster. Our positional criteria are $12^h \leq \alpha < 13^h$, $+5^\circ \leq \delta < +20^\circ$, with the exception of $12^h 15^m \leq \alpha < 12^h 45^m$, $+8^\circ \leq \delta < 16^\circ$. Since many of the

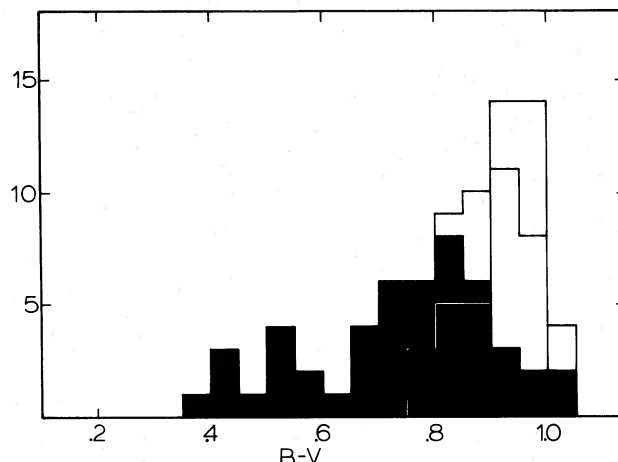


FIG. 4.—*Solid histogram*, color distribution of a spiral-rich population; *filled area*, spirals; *open area*, E's and S0's. *Line histogram*, color distribution of galaxies within R_{30} of the Virgo cluster.

galaxies in the SRC do not have measured velocities, selecting objects near Virgo (most of which will be members of the local supercluster) allows us to approximate an absolute magnitude limited sample. To this group we add all of the spirals from the inner part of Virgo and that fraction ($\frac{1}{2}$) of the ellipticals and S0's necessary to maintain the correct fraction of spirals. This sample of 78 galaxies contains 40% E+S0, 23% S0/a–Sab, 18% Sb–Sbc, and 19% Sc–Irr galaxies, a mix very similar to that in Hercules and other spiral-rich clusters. The color distribution of this population is presented in Figure 4, where spirals occupy the filled area and E's and S0's the remainder. This distribution has two notable features. First, even though the majority of galaxies are spirals, the distribution is strongly peaked at the color of the E's and S0's. Also, approximately one-third of the spiral galaxies have colors as red as or redder than the E/S0's.

With the color distributions of Figures 2 and 4 in mind, we have adopted the following procedure for estimating the spiral content of a cluster. One must first choose a color system in which the colors of the E/S0's are symmetrically distributed about the peak. In practice, this means that the color-magnitude effect must be removed, which we have done by using Figure 2 of Visvanathan and Sandage (1977). Next, we determine the ratio of galaxies to the blue and to the red of the peak; any excess number to the blue are considered spirals. Finally, to take account of the red spirals, we multiply the number of excess blue objects by 1.5. This factor, of course, will only be correct if the color distribution of the spirals is like that in Figure 4. Since we have no independent information to the contrary for our other clusters, this approximation is the best we can do. However, it is worth noting that in the very different spiral-poor population in Figure 2, the color distribution of the spirals is not noticeably different from that in Figure 4.

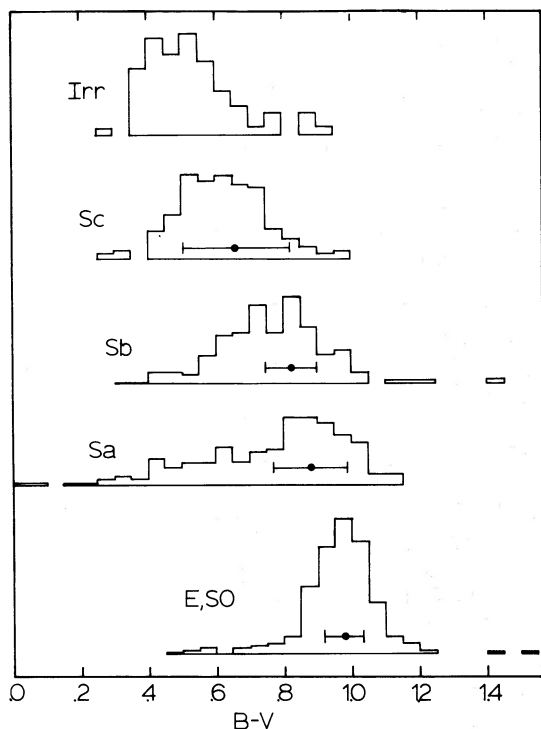


FIG. 3.—Color distribution of various morphological types of field galaxies, from the SRC. Also indicated are $\langle B - V \rangle$ and $\sigma(B - V)$ of cluster galaxies.

The BV photometry which we have used to determine the spiral content of our sample clusters comes from several sources and is of variable quality. That of A1413 and A1689 is our own vidicon photometry and will be described in the next paper in this series. The photometry of A154, A168, and A2256 was very kindly made available in advance of publication by Dr. Alan Dressler. The data on these five clusters are quite good. Of somewhat lower quality is the photometry of A2255 by Borngen and Kalloglyan (1977). As published, this photometry contains a gross (~ 0.3 mag/mag) magnitude-dependent color error, but after correction for this it appears reasonably good. Following the procedures described above to analyze the color distributions obtained from this photometry, we obtain spiral contents which are included in column (5) of Table 1.

The uncertainties assigned to these latter spiral fractions need some comment. In addition to the errors introduced by small number statistics, there is some error due to misdetermination of the E/S0 peak in the color distribution. If a cluster contains only elliptical and S0 galaxies and if the photometry has small errors, the total color spread will be small and the peak well determined. If, however, the color distribution is wide, due *either* to a large spiral content or to large photometry errors, the peak will be poorly determined. In A154 and A168 it was difficult to decide how much of the color spread was due to each of these two factors, especially as the accuracy of the photometry was not accurately known, nor was there a well-determined zero point for the color system. The large uncertainties attached to the spiral fractions in these two clusters reflect the uncertain interpretation of the color distributions of the clusters.

IV. DISCUSSION

The results from Table 1 are plotted in Figure 5 and are gratifyingly unambiguous. No nearby cluster of

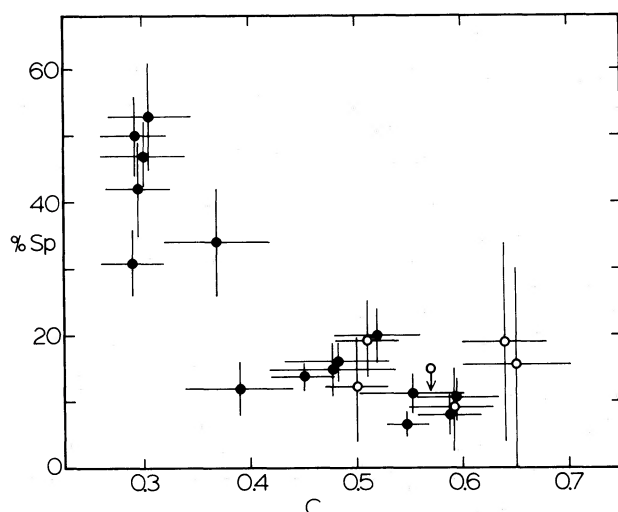


FIG. 5.—Spiral content versus central concentration in sample clusters.

high central concentration contains a large population of spirals in its core. In fact, with the exception of the Virgo cluster, spirals are found in large numbers only in those irregular clusters with *no* central concentration. Thus the long-held qualitative impression of the relation between cluster structure and galaxy content appears to be almost universally true. We have also determined the concentration and spiral content of the two very distant clusters discussed in our previous paper, and these results are included at the end of Table 1. The reader is invited to add these points to Figure 5 in order to see how strikingly the distant clusters differ from the nearby ones.

Despite the seeming improbability that our two distant clusters are drawn from a parent population represented by our 21 nearby clusters, we do not regard this as totally established. The distant clusters have been found by observations in passbands which are quite far in the blue in the emitted frame, which produces a strong selection effect in favor of clusters containing blue galaxies. It is possible, though not established, that the limits on nearby spiral-rich concentrated clusters must be lowered to much less than one in 21 before the contrast with the distant cluster population will become significant.

Evolutionary questions aside, the results presented in Figure 5 are interesting for their own sake. The most straightforward interpretation of these data assumes that the presence or absence of central concentration is an indicator of whether or not a cluster has collapsed and relaxed. The strong correlation of C with spiral content then supports the idea that stripping is responsible for the lack of spirals in the high C clusters. It is interesting that we seem to have found only one transition cluster, Virgo, which has apparently relaxed but which has not yet lost all of its spirals. If we are seeing, among our objects, clusters of every stage of their dynamical evolution, a fact which is by no means certain, then the fraction of spiral-rich collapsed clusters is an inverse function of the efficiency and speed of the stripping mechanism.

We feel quite confident that Virgo *is* a transition object. Even though its central concentration is quite low, Virgo displays the smooth mass distribution and radial population gradient found only in the concentrated clusters. Also, its spiral content, although high, is significantly different from that of the spiral-rich clusters. Superposed on the spiral-rich color distribution in Figure 4 is the color distribution of the galaxies within R_{90} in Virgo. The Virgo colors are much less skewed toward the blue than those of the spiral-rich population, a result which could have been inferred from van den Bergh's (1976) discussion of the "aneimic" spirals in Virgo.

The Virgo cluster may, therefore, be providing us with a unique example of a cluster in the process of losing its spirals. It may also be no coincidence that it is the nearest moderately rich cluster of galaxies. Clusters in this evolutionary state have evolved more slowly than those which have completed their stripping, and are therefore of lower mean density. It is

possible that they are noticeable as clusters only if they are as close as Virgo. In this case, our cluster sample would be deficient in these newly formed objects, and stripping may not be nearly as effective as we would otherwise conclude.

We wish to express our gratitude to Dr. Sverra Aarseth for the use of his numerical cluster models, to Dr. Alan Dressler for sending us his unpublished photometry, and to Dr. Jerry Ostriker for pointing out the selection effect discussed above.

REFERENCES

- Abell, G. O. 1958, *Ap. J. Suppl.*, **3**, 211.
 ———. 1965, *Ann. Rev. Astr. Ap.*, **3**, 1.
 Austin, T. B., and Peach, J. V. 1974, *M.N.R.A.S.*, **168**, 591.
 Bahcall, N. A. 1973, *Ap. J.*, **186**, 1179.
 ———. 1974, *Ap. J.*, **187**, 439.
 ———. 1977, *Ann. Rev. Astr. Ap.*, **15**, 505.
 Baier, F. W. 1976, *Astr. Nach.*, **297**, 295.
 ———. 1977, *Astr. Nach.*, **298**, 151.
 Borngen, F., and Kalloglyan, A. R. 1977, *Astrophysics*, **13**, 1.
 Butcher, H., and Oemler, A. 1978, *Ap. J.*, **219**, 18.
 de Vaucouleurs, G., de Vaucouleurs, A., and Corwin, H. G. 1976, *Second Reference Catalogue of Bright Galaxies* (Austin: University of Texas Press) (SRC).
 Dressler, A. M. 1976, Ph.D. thesis, University of California.
 Noonan, T. W. 1972, *A.J.*, **77**, 9.
 Oemler, A. 1973, Ph.D. thesis, California Institute of Technology.
 ———. 1974, *Ap. J.*, **194**, 1.
 Omer, G. C., Page, T. L., and Wilson, A. G. 1965, *A.J.*, **70**, 440.
 Rudnicki, K., and Baranowska, M. 1966, *Acta Astr.*, **16**, 55.
 Sandage, A. R. 1972, *Ap. J.*, **176**, 21.
 van den Bergh, S. 1976, *Ap. J.*, **206**, 883.
 Visvanathan, N., and Sandage, A. 1977, *Ap. J.*, **216**, 214.
 Weedman, D. W. 1975, *Ap. J.*, **195**, 587.
 White, S. D. M. 1976, *M.N.R.A.S.*, **177**, 717.
 Zwicky, F., Herzog, E., Wild, P., Karpowicz, M., and Kowal, C. T. 1961–1968, *Catalogue of Galaxies and Clusters of Galaxies*, 6 vols. (Pasadena: California Institute of Technology).

HARVEY BUTCHER: Kitt Peak National Observatory, P.O. Box 26732, Tucson, AZ 85726

AUGUSTUS OEMLER, JR.: Yale University Observatory, Box 2023 Yale Station, New Haven, CT 06520